# ENGINEERING NEWS
AND
## AMERICAN RAILWAY JOURNAL.

VOL. XLII. No. 20.


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THE NEW EAST RIVER BRIDGE COMMISSION invites proposals, to be opened on Dec. 7, for furnishing the materials and constructing steel cables and suspenders, cable-bands and sheaves for the bridge. Specifications and drawings can be obtained from the Chief Engineer, at No. 84 Broadway, Brooklyn. Each bid requires a certified check for $12,000, with the proposal, and a bond of $400,000 on the part of the successful bidder.

THE NEW YORK RAPID TRANSIT RAILROAD Commission has advertised for proposals for constructing, equipping and operating under lease the proposed underground rapid transit railway in New York city. Bids will be received until Jan. 15, 1900, at the office of the Commission at 320 Broadway, New York city, where the specifications, forms of contract, etc., can be examined. The contract is to be awarded within 30 days after receipt of the bids, if a satisfactory bid is obtained.

THE MEMORIAL BRIDGE ACROSS THE POTOMAC River, at Washington, D. C., which has been discussed at intervals for nearly 15 years, has a reasonable chance of being begun in the near future. The first suggestion to build a memorial bridge across the Potomac River to connect the city of Washington with the National Cemetery at Arlington was in 1886, when Congress appropriated $2,500 for making soundings and borings. With this money a survey was made for the proposed bridge. The engineers making this survey asked for a further appropriation of $5,000 to pay for engineers' designs and estimates for a bridge. This appropriation was also granted by Congress. The following engineers were asked to submit designs: Mr. Geo. S. Morison, M. Am. Soc. C. E., Mr. L. L. Buck, M. Am. Soc. C. E., Mr. Wm. R. Hutton, M. Am. Soc. C. E., and Prof. Wm. H. Burr, M. Am. Soc. C. E. The plans of these engineers are to be submitted on Jan. 16, 1900. It is stated that President McKinley will urge that the bridge be constructed in his coming annual message to Congress, and that the Speaker of the House of Representatives and other leading Congressmen have expressed the intention of supporting the bill for its construction, which will be introduced into Congress. The cost of the bridge has been estimated at from $1,000,000 to $5,000,000, and it will be designed as a memorial of the soldiers and sailors of the United States who have died in war.

THE CHICAGO DRAINAGE CANAL was visited Nov. 7 by a large party of persons who are interested in the work from different points of view. The trip was arranged by the Trustees of the Sanitary District, largely with the intention of showing the canal to several of the members of the national legislature, since the canal and its relations to the navigation of the Great Lakes and the health of the community may come up at the next meeting of Congress. Besides the Trustees and officials of the Drainage Board (including Mr. Isham Randolph, Chief Engineer, and Mr. Thomas T. Johnston, Consulting Engineer), there were representatives of the Special Canal Commission, the State Executive, the city council and departments, and a number of members of the state and national legislatures. The party filled two trains of ten cars each on the Atchison, Topeka & Santa Fe Ry. Stops were made at various points, including the works for the eight-track bridge, Willow Springs, Lemont, Romeo and Lockport. Lunch was served in the cars at the latter point. The first train left at 9.45 a. m., and arrived on its return at 5 p. m.

THE ILLINOIS RIVER VALLEY ASSOCIATION, with the view of pushing the construction of a deep waterway from the end of the Chicago drainage canal to the Gulf of Mexico, has appointed a legislative committee to take charge of the active work at Washington, with Mr. Lyman E. Cooley, heading the Chicago delegates. This committee is to lay before Congress the necessity of beginning this deep waterway by deepening the Des Plaines and Illinois Rivers from Lockport to the Mississippi. Congress will be asked to appoint a board of engineers to survey and investigate the route and to estimate the cost of the improvement.

A TUNNEL FOR TELEPHONE CABLES is being built at Chicago by the Illinois Telephone & Telegraph Co., which is a new independent company. The tunnel will extend from Fullerton Ave., on the North Side, south to 55th St., with a branch westward to Western Ave. It will be 4 ft. wide and 7 ft. high, lined with concrete, and will be fitted with racks for the wires and cables. The crown is about 30 ft. below the street level, so as to avoid interference with sewers and pipes. It was expected that no trouble would be caused from disturbance, but work was stopped recently by order of the Department of Public Works on complaints that certain buildings were affected. The company, however, claims that its photographs and records show that the cracks which led to the complaints existed before work was commenced on the tunnel. The company has also had trouble with the labor organizations, by whom a strike of the men employed has been ordered in an endeavor to compel the company to use bricks instead of concrete for the lining.

THE TRANS-PACIFIC CABLE SURVEY, now being conducted by the U. S. government between Honolulu and the Philippines, by way of Midway Island and Guam, reports that two offsets are necessary owing to obstacles encountered. One of these is a submarine mountain rising 2,200 fathoms above the floor of the ocean and coming to within 82 fathoms of the surface; in other words, this mountain is 13,200 ft. high. The second obstacle is one of the deepest submarine valleys, or clefts, yet found in the world; soundings show a depth of 4,900 fathoms, or 29,400 ft. below the ocean surface. With the offsets thus required the route is entirely practicable for a submarine telegraph cable.

A NEW PACIFIC CABLE BILL has been prepared for introduction into the next Congress, in the interest of the Pacific Cable Co., of New York. This bill proposes to cut the present tariff charges almost in two, and to establish communication between Guam and Yokohama. If the U. S. government will contract to use the cable for 20 years and pay a subsidy of $400,000 a year for this period, the company will begin construction at once, on a route extending from San Francisco to Honolulu and thence by Guam to Manila, with a branch cable from Guam to Yokohama. It would be agreed that the rates for private messages, from San Francisco to Yokohama, should not exceed $1 per word; the present rate, by the Eastern Telegraph Co., is $2.27 per word, and by the Great Northern, it is $1.86 per word. The same rate of $1 would prevail to Manila, as compared with $2.47, the present rate. The cable would be free to the government for 20 years, and thereafter cost half the prevailing rates. The President of the Pacific Cable Co. is James A. Scrymser, President of the Mexican Telegraph Co. and the Central & South American Telegraph Co., now operating 14,000 miles of cable. Mr. E. L. Baylies is Vice-President.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Michigan Central R. R. at La Salle, Mich., on Nov. 9. The Toledo and Detroit express was ditched by the spreading of the rails, resulting in probably fatal injuries to three persons. The officials of the road have evidence showing that the fish-plates had been removed, and are offering $2,500 reward for the apprehension of the miscreants.

THE CRUISER "CHARLESTON," was wrecked on Nov. 2, on an uncharted reef, about 30 miles northwest of the Gulf of Lingayen, in Luzon. The crew and officers were all safely landed on Kamiguin Island, among friendly natives. The ship lies well out of water, and orders have been issued for wrecking apparatus from Hong Kong to be sent to the spot, and an attempt made to raise her. The "Charleston" is a protected cruiser of 3,042 tons, launched at the Union Iron Works, of San Francisco, Dec. 5, 1885. She had a crew of 33 officers and 426 enlisted men, and carried two 8-in. and six 6-in breech-loading rifles and a powerful secondary battery.

THE BESSBROOK & NEWRY ELECTRIC RAILWAY, in Ireland, accommodates street cars and wagons. It is of 3-ft. gage, 3 miles long, with a rise of 180 ft. The track is built of steel T-rails, outside of and adjoining which is a lower line of steel rails. The wagons, without flanges on the wheels, run on the lower outside rails; the inner rails for the cars are high enough above the outer rails to act as a guide to the wagons, keeping them on the track. At either end of the line the wagons are detached from the train and taken to their destination over the regular streets and roads by horses. There are no terminal charges, so the cost of handling is light. There is no delay or difficulty in getting the wagons on or off the ends of the line. The cost of the road, including land, was about £16,000 ($77,860), and the line has been in operation for 16 years.

STEAM MOTOR VEHICLE DRIVERS, in Washington, D. C., must hereafter pass an examination and take out a license for running such vehicles on the public ways, at a cost of $3. The District Commissioners apparently only enforce this law in the case of vehicles driven by steam, and they require all boilers to be annually inspected by the proper authorities.

MOTOR VEHICLES FOR CARRYING THE MAIL are to be tried in Chicago, and the Post Office Department is asking proposals for such service between the general post office and to sub-stations in the business center of Chicago. This service is to be compared in cost and efficiency with mail delivery by screen wagons and electric car service.

THE PNEUMATIC POSTAL-TUBE SERVICE, in New York, is now working admirably, says Postmaster Van Cott, and he is asking for its extension to 125th St. At present the service includes one conduit connecting the General Post Office with Brooklyn, and the others lead to the Produce Exchange; to Madison Square; to Station D, at Bowery and 6th St.; and to Station H, at Lexington Ave. and 44th St. The latter line is employed for all mail going out from the Grand Central Station, and is the most used. It is estimated that 800,000 letters are sent daily through this conduit. They pass over a distance of 3¾ miles in 7 minutes, using about 2,000 "carriers" per day. These carriers are steel tubes, 28 ins. long by 6 ins. diameter, and hold about 300 letters each, or any package less than 6 ins. diameter.

A NOVEL APPLICATION OF THE FLEXIBLE SHAFT principle is its employment as a means of propelling small pleasure craft, made by Henschell & Co., of Berlin. The motive power is a 2-HP. vertical naphtha engine, taking up but little room in the stern of the boat. This engine transmits the power to the propellor through a flexible shaft passing through a curved steel tube, leading over the stern of the boat. This curved tube, besides carrying the propellor at its end, is also fitted with a rudder, and is moved by a tiller. The whole apparatus can be quickly fitted to any small pleasure boat.

THE "HOLLAND" SUBMARINE BOAT was tested on Nov. 7 by the Board of Survey and Inspection of the U. S. Navy Department, Rear-Admiral Frederick Rogers, chairman. The test was made off Greenport, L. I., in water 20 ft. deep. The run of one measured mile, submerged 10 ft. below the surface, was made in 9 minutes; the Holland then rose, discharged a Whitehead torpedo and disappeared in 10 seconds. The torpedo weighed 840 lbs., and was discharged from the bow tube, and at a range of 400 ft. it passed within 25 ft. of the target flag; the torpedo had no war-head, and traveled 800 ft. The "Holland" then turned under water in 1½ times her own length of 54 ft. With decks awash and against a strong ebb tide she made 8 knots speed. The board expressed itself, unofficially, as surprised and delighted with the success of the trial in all requirements. The "Holland" was built in 1896 at the Nixon shipyard, and cost about $300,000; but she could be duplicated for about half that sum. She is 54 ft. long, cylindrical in cross-section, and 9 ft. in diameter amidships. It is the sixth boat built by Mr. John P. Holland, and the present craft will be taken to Washington in a few days for further inspection. She will make the trip through the Raritan Canal, and be lightened to 8 ft. by pontoons.

A NEW ABERRATION CONSTANT FOR POLARIS, of 20.58 seconds has been obtained by Prof. Asaph Hall, Jr., director of the astronomical laboratory of the University of Michigan, as the result of observations made between May, 1898, and July 1, 1899. It has become certain that the old constant, 20.44 seconds is incorrect, and the work of determining the correct constant is being carried on by a number of observatories. At the Cape of Good Hope observatory, the constant obtained was 20.57 seconds; at the University of Pennsylvania, 20.58 seconds; at Naples, 20.66 seconds; and at Columbia University, 20.48 seconds. The aberration constant is the apparent displacement of the star in the direction of the relative motion of the earth, and is due to the latter.

## TWO RAILWAY PILE-DRIVERS.

(With two-page plate.)

The railway pile-driver, or track pile-driver, is an important feature of modern railway equipment. It is frequently in requisition for the construction of new foundations, the renewal of timber trestles and bridges, and the construction of temporary structures at washouts, etc. In the June number of the "Journal of the Western Society of Engineers" is a paper by Mr. G. W. Smith, Assistant Superintendent of Bridges and Buildings, of the Chicago, Milwaukee & St. Paul Ry., describing a somewhat novel pile-driver designed by him, and built at the company's car shops, at West Milwaukee, Wis. This machine, with some modifications introduced in the design, we illustrate this week, from photographs and blue prints furnished us by Mr. Smith, through the courtesy of Mr. Onward Bates, M. Am. Soc. C. E., Engineer of Bridges and Buildings, C., M. & St. P. Ry.

The machine consists of a heavily-built flat car, upon the floor of which is a steel intermediate deck (or turntable bed) carrying the turntable and end supports of the upper deck (or engine bed). This engine bed consists of longitudinal timbers extending the full length of the car, and trussed by rods passing over a central tower. At the front end of the bed are the leaders, while at the rear are the hoisting engine and boiler, enclosed in a housing or cabin. For ordinary work the machine is used in the position shown in Fig. 1, with the leaders just in front of the end sill, and the bed held in place by hooked bars attached to the car framing. If it is desired to drive piles in advance of the machine, as in rebuilding a trestle that has been washed out, the entire machine is run forward on rollers carried by the turntable bed, which run on flat rails on the floor of the car. The extreme distance of this longitudinal travel is 18 ft.

For work at either side of the track, the machine is revolved upon its turntable and can be turned at right angles to the track, with an extreme reach of 22 ft. 6 ins. from the center of the track to the leaders. The engine and boiler being mounted on the upper deck, act as a counterbalance, and the weights on the deck are so adjusted that the center of gravity is never outside of the center circle, 9 ft. in diameter, upon which the deck rests. In this position, a pile can be picked up, placed and driven with perfect safety. Another special feature of the machine is that the leaders can be swung in a vertical plane, at right angles to the bed, and can thus be inclined at any desired angle for driving brace or batter piles.

One of the most novel and striking features of the design, however, is the way in which the leaders are lowered for transportation, by means of a bascule arrangement. A segmental frame is attached to them, and rolls back upon the machine bed, bringing the leaders downward and backward until they lie in a horizontal position, just above the roof of the cabin. In this position the hammer lies just over the vertical member of the bascule attachment, and is thus well supported. This position is shown in Fig. 1 by dotted lines. The total height, when arranged for transportation, is 16 ft. 8 ins. above the rail. Fig. 2 is a view of the machine ready for transportation, in which position it can be coupled direct to a car or engine at either end, without the intervention of a long coupling bar, as is sometimes required. Fig. 3 shows it in position for driving piles ahead of the car, the engine bed having been run forward along the floor of the car. Fig. 4 shows it swung at right angles to the track, and Fig. 5 shows the leaders inclined, as for driving batter piles. The machine is not self-propelling.

From Figs. 1 and 6 it will be seen that the car is 45 ft. long, with side sills 6¼ × 17 ins.; center sills, 7 × 12 ins.; and four intermediate sills, 7 × 10 ins. There are also sub-sills, 5 × 7 ins., under the center sills. The end sills are 8¾ × 11 ins. This framing is trussed longitudinally by six rods, 1½ ins. diameter, upset to 1¾ ins. at the threaded ends. All these rods pass through the end sills. The truss depth is 10 ins. and the struts are attached to needle beams 5 × 8 ins. The body bolsters are of iron, with a horizontal top plate and lower truss plate, the ends of which are bent to receive the end sills. On top of each side sill is a plate 1 × 4 ins., extending across the end sills. Similar plates, 1 × 3 ins., are on the four intermediate sills, all being secured by ⅝-in. bolts with countersunk heads. These plates form the rails along which the engine bed travels. Midway between the bolsters and needle beams, and at the middle of the car, are blocks 3 × 4¼ ins. fitted between the sills, with a ¾-in. tie rod extending through from side to side at these points. The draft rigging is placed between the center sills, and the car is fitted with M. C. B. couplers and the Westinghouse brake. It is mounted on a pair of steel trucks of the Barber pattern, having diamond frames and steel channels for the transoms. The wheels are of cast iron, 33 ins. diameter. The truck wheelbase is 5 ft., and the total wheelbase of the car is 34 ft.

Fig. 7 is a plan of the upper deck or engine bed, which rests on the turntable, and is supported at the ends by rollers on a curved roller path. This frame consists of four timbers, 12 × 12 ins., 45 ft. long, with the center casting and the roller circle plates placed under them. At the rear they are framed into a sill 10 x 12 ins., while at the front they are connected by a box girder formed of two 10-in. channels, 12 ins. apart, with the flanges set inward. This girder is let 1½ ins. into the timbers, and is supported by brackets or gussets at the rear, while its face carries the curved channel which serves as a guide to the leaders when being swung laterally. Across the middle of the bed are two girders, each formed of two 8-in. channels, and these support the four posts of oak timbers, 8 × 8 ins. for the central tower. The posts are braced by diagonal timbers 6 × 6 ins., and support the ends of two side plates 7½ × 3 ins. These are 26 ft. 5 ins. long, and extend back to the rear of the cabin. These posts are 6 ft. 6 ins. apart in the clear, and their tops are 9 ft. 2 ins. above the floor. Across each side of this frame or tower passes a truss rod, 1½ ins diameter, with ends upset to 1¾ ins. One end is anchored to the rear sill and the other to the box girder above mentioned, the rods being set up to the proper tension by means of turnbuckles.

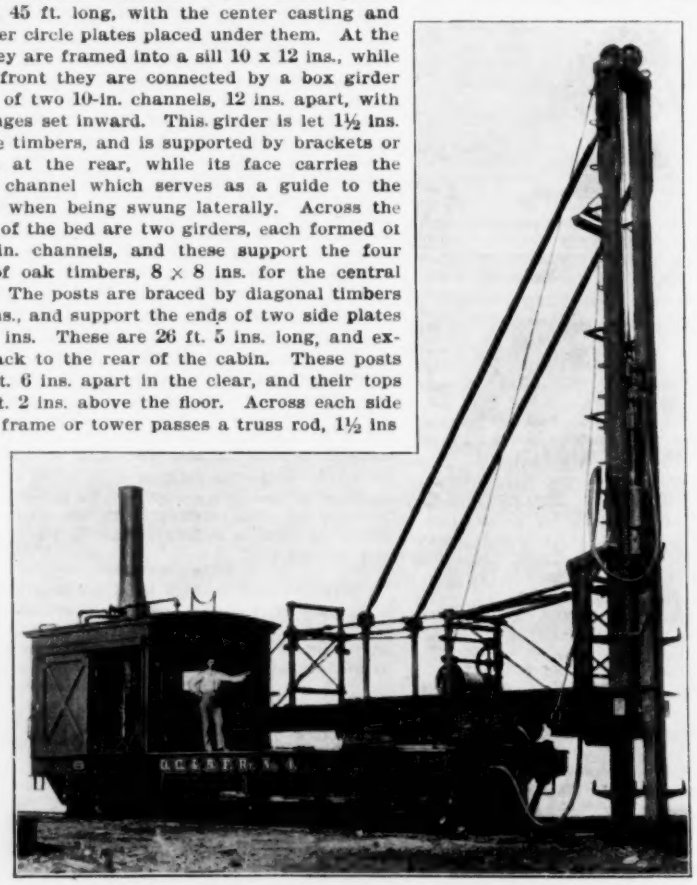


FIG. 10.—TRACK PILE DRIVER, WITH STEAM HAMMER; GULF, COLORADO & SANTA FE RY.
Industrial Works, Bay City, Mich., Builders.

The intermediate deck or turntable bed, which lies between the engine bed and the car floor, is shown in Fig. 8. From this it will be seen that the turntable and the end bearings are carried by six pairs of 5-in. channels, 32 ft. long, set back to back, and having rollers journaled in the webs. These rollers run on the flat plates bolted to the sills, as already described. The rollers are of cast iron, 5 ins. diameter and 3 ins. wide on the face. Those for the outer rail (on the side sills) are plain, but those for the inner rails (on the intermediate sills) have ½-in. flanges. The details of these rollers and their fittings are shown in Fig. 9. There are 48 rollers in all. Fig. 9 also shows the 4½-in. rollers used for the turntable and the end racks, there being 20 in the swing circle and 7 at each end. The longitudinal channels are tied together transversely by the circular and segmental channels for the turntable rollers and end rollers, and by end plates ½ × 5 ins. There is also an X-bracing of four pairs of diagonal plates ¼ × 6 ins., laid across the channels (above and below) and riveted at each intersection. These provide for racking strains in the swinging of the machine.

In order to provide as broad a base of support as possible, when the engine bed is swung transversely to the track, and is making a long reach, the truck transom channels are made long enough to extend under the side sills. Saddle plates across the transoms carry jack screws, which can be turned up to bear against the sills, thus giving a direct bearing on the truck and the rails, and preventing any tipping due to compression of the springs under the load. This may be seen in Figs. 2 and 3.

The following particulars of the machine and its operation are taken from the paper by Mr. G. W. Smith, above referred to:

The first step toward preparing the driver for service is to move the driving deck ahead so that when the leaders are in an upright position they will not interfere with the coupler on the end of the car. This movement of the deck is accomplished by operating the capstan near the front. The motion is transmitted through a sprocket chain between the two center sills of the deck to a sheave at the center of the deck, which operates a vertical shaft on which is a pinion which engages a rack along the side of one of the center sills. The movement forward and back is permitted by the intermediate deck, on which are carried the center on which the driver swings and the circular racks by which the swinging is accomplished.

The construction which accomplishes the raising and lowering of the leaders is unique, and, so far as the writer knows, is not to be found on any other pile-driver. By reference to the cuts, a pair of rockers will be seen, the outline of which is a quadrant of a circle. These rockers are a part of the framework to which the leaders are secured, and as they pass gradually from a horizontal to a vertical position, the rockers continue to rest on the deck, the point of contact passing to the front until the leaders are in an upright position.

The leaders are supported at a point 20 ft. above the deck, which is at the apex of a four-cornered tower. The two legs of this tower on the side nearest the observer consist of a pair of angles over the front corner of the deck, and a diagonal ladder behind, and are matched on the further side by two members which serve the same purpose, although the rear one is not a ladder. The fixed portions of this tower are the A-frame in front, the rockers with their radial struts, the platform 7 ft. above the deck and two rear braces from this platform up to the apex of the tower. That portion of the rear braces which extends from the platform down to the deck is hinged and jointed to permit the rocker to roll back when the leaders are to be lowered. The connection at the platform and at the deck is a plain pin. The connection at the middle has two pins, only one of which is removed when the leaders are to be lowered. The result is that this portion of the rear brace folds up like a jackknife, but at no time is the tie between the apex of the tower and the deck of the driver entirely broken. This prevents any chance that the leaders, with the framework attached, might go clear off the end of the driver if carelessly raised.

The tread for the rocker is of T-shape, with the head laid on the deck. The rocker itself consists of two plates with a filler between, one plate riding on each side of the

upright leg of the T. Round notches in the rocker to match pins in the tread prevent the former from getting out of place in operation. This method of raising and lowering the leaders is remarkably satisfactory, because with the hammer properly located in the leaders (just level with the end sills) they are so nicely balanced that with the use of very little power they can be started from either the horizontal or vertical position, and once started they will continue their motion, reaching the opposite position without jar. The rocker, instead of being a true circle, is slightly flattened, with the result that if the leaders were left to assume a normal position they would remain on an incline. Therefore, when they are started either down or up it is necessary to give them a sufficient motion so that the momentum will just carry them to their proper position. When the leaders are lowered, the hammer is drawn up until it comes opposite the platform, and is thus given support because the platform at that time has its lower edge resting on the deck.

The points of great value accomplished by this design are that the leaders are so nicely balanced that they can be raised and lowered without making any outside hitches, and when lowered they are so far back on the car that the ends do not overhang, and thus prevent coupling with box cars.

The swinging of the deck is accomplished by operating pinions which engage the circular racks attached to this intermediate deck. There is one short section of circular rack at each end of the intermediate deck, and at the center is a complete circle by which the deck can be swung clear around. So long as the ends are over this intermediate deck they are partly supported and enabled to move freely by rollers, but after swinging clear of these, the deck is balanced by the proper arrangement of the load. The pinions for swinging the deck are operated by ratchet levers.

Another railway pile-driver, of quite different construction, is shown in Fig. 10. The car framing is of oak, well trussed, and mounted on a pair of steel trucks. The turntable is on the front end of the car, and the horizontal bed of the steel leader truss projects normally 7 ft. beyond the car. This truss can be run ahead so as to drive piles 16 ft. in advance of the car, and can be swung round at right angles to the track, but it is entirely independent of the engine and boiler, which are permanently attached to the car framing. Mounted upon the truss is a hand hoist, which can be used for raising and lowering the leaders, hauling on piles to hold them upright, etc.

The leaders are pivoted to the brackets on the short posts on the end of the leader truss. In arranging the machine for transportation, the stay rods are detached from the top of the leaders and lowered to an approximately horizontal position. The leaders swing backward to a horizontal position, the head-frame resting on the cross-piece at the rear end of the truss. The lower end, below the pivot, projects in front of the truss, the beams of which, as already noted, project 7 ft. in front of the car. A flat car must therefore be coupled to the pile-driver to enable it to be coupled into a train. The machine, however, is self-propelling, and can travel at a speed of about five miles per hour, so that while working it does not require the constant service of a locomotive. In a special make of the machine, the leaders can be inclined by means of a worm gear in order to drive batter piles. The weight is about 84,000 lbs., and when arranged for transportation the extreme height is 14 ft. 6 ins.

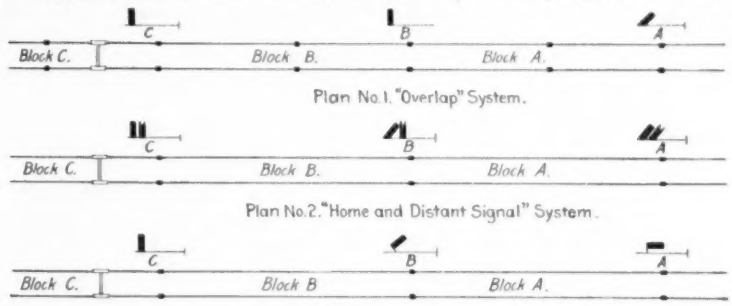
This pile-driver was built for the Gulf, Colorado & Santa Fe Ry., and is equipped with a steam pile hammer instead of the ordinary drop hammer. The usual high-speed friction hoisting engine is also fitted, so that a drop hammer can be used if desired. The steam hose to the hammer is looped up at the side of the leaders, and is attached to a pipe carried under the floor of the car and extending through the end sill. For photographs and particulars of this machine we are indebted to the builders, the Industrial Works, of Bay City, Mich.

## POSSIBILITIES OF THREE-POSITION SIGNALING.*

By Frank Rhea.†

Let us first consider the possibilities of three-position signals, used to give the indications with an automatic block system. As automatic block signals are installed to-day, we are limited to two systems. The first, shown by plan No. 1, is known as the "over-lap system." The second, which is shown by plan No. 2, is the "home and distant signal system." The proposed "three-position system" is shown by plan No. 3. As is well known, the "over-lap system" is composed of home signals only, and the indications are so arranged that a train entering block (A) throws signal (A) to the danger position. The train passing into block (B) throws signal (B) to danger, and still holds signal (A) in the danger position, until the rear of the train has passed a prescribed point beyond signal (B). It then releases signal (A), allowing it to go to the clear position, but still holds signal (B) in the danger position—and so on through each block.

The "home and distant signal system" consists of a home and distant signal placed on the same mast. A train entering block (A) (plan 2) throws home and distant signal at (A) to the danger and caution positions, and when the rear of the train has passed out of block (A), home signal (A) is released and goes to the clear position, but the distant signal (A) still remains in the caution position. The train in passing into block (C) throws the home and distant signals (C) to the danger and caution positions, and when the rear of the train has passed off of block (B), home signal (B) will be released and go to the clear position, when distant signal (A) will also indicate clear.




The proposed system, as shown by plan No. 3, consists of one home signal for each block. The train entering block (A) throws signal (A) to the danger position. The train entering block (B) throws signal (B) to the danger position, and when the rear of the train has cleared block (A), signal (A) assumes the middle or caution position (showing a green light at night) indicating that block (A) is clear but that home signal (B) is in the danger position. The train entering block (C) throws signal (C) to the danger position, and when the rear of the train has cleared block (B), signal (B) assumes the middle or caution position (showing a green light at night) and signal (A) assumes the clear position—indicating that block (A) is clear, and that signal (B) is either in the caution or clear position. It thus gives the completeness of information that is given by the home and distant signal system, but requiring the reading of but one signal only at a time, for this completeness of information.

It is generally admitted that the principle of the over-lap system has not proved satisfactory, and that by using it you either retard your speed of trains, which limits the volume of business to be handled over your tracks, or (if you do not retard your speed) you do not derive all the benefits and safeguards which it is possible to obtain from a system of automatic signals. This is due to the fact that you do not have any caution or advance indication of the condition of the next block in advance. By this I mean that you can get a clear signal at one block, and an absolute stop signal at the next block.

The "home and distant signal system" and the "three-position system" give the same completeness of information, as they both show the condition of two blocks in advance. I think it will be readily admitted, however, that the "three-position system" gives its indications more simply and to the point, and that it is easier for the trainmen to read and interpret these indications quickly. Other things being equal, the simpler apparatus or method is always the best.

From an economical standpoint the "three-position system" has the advantage of considerably less cost in expense of installation over the "home and distant signal system;" in fact, the cost of installation is only slightly increased over that of the over-lap. From a maintaining standpoint, it is probably considerably the cheapest of the three, and from an operating standpoint, the expense should be exactly the same as the "over-lap system," with the same number of signals, and decidedly less than the "home and distant signal system." It will be appreciated where this occurs from the fact that we have but half the lamps that we do with the "home and distant signal system," and when it is considered that it costs something like $12 a year, in labor and oil, to operate one lamp.

Let us now consider the three-position signal used in connection with interlocking. It has become the generally prevailing practice to use two arms on all high, home, interlocking signals, where there is a high speed route and one or more slow speed or diverging routes; the top arm governs the high speed route, and the lower arm all the slow speed or diverging routes. The proposed arrangement of the three-position signal would govern the high speed route when the signal is in the vertical position—or shows a white light at night. When the arm is inclined 45°, or shows a green light at night, it would govern the slow speed, or diverging routes. With this method of signaling we would make a characteristic difference between the high speed route and the diverging routes, and would carry out in practice, the giving of a low speed or caution signal, when a movement is to be made at a low speed. At present the usual practice is such that, if one of the lights goes out at night, the engineman has no means of ascertaining whether he is receiving the indication for the high speed route or the low speed route, except as he may be able to remember at which heights the respective signals are located.

The three-position signal used in connection with interlocking has decided advantages in the way of economy, as has the three-position automatic system. It would require only one-arm poles, which in itself would be a considerable saving. A three-position signal, however, would have to be operated with pipe connections, but as it is the practice on a number of roads to use pipe-connected home signals, this would still effect the saving of the connections to the lower arm. This, of course, would mean proportionately fewer number of connections to be maintained, and care of the small number of lights would mean in its turn a corresponding saving.

*Condensed from a paper presented at the annual meeting of the Railway Signaling Club at Boston, Mass., Nov. 14.

†Signal Inspector of the Pennsylvania Lines.

## PROPOSED DESIGN FOR A STEEL AND CONCRETE DAM

By John S. Fielding, Civil Engineer.*

In the opinion of the writer, no modern dam utilizes, in its design, all the means now at hand for the building of a permanent, economical and absolutely trustworthy structure of this type Though dams are among the very earliest of engineering efforts, more uncertainty still exists as to the proper methods to be pursued in insuring stability than in the case of almost any other structure. In the case of bridges, buildings, machines, etc., engineers are almost a unit in regard to the manner of estimating their strength, efficiency and factor of safety; and with given loads and conditions of loading they can check each other's designs, and individual responsibility is largely eliminated, for each engineer feels that he is supported by the general practice in such cases. If such a condition of intelligent common practice could be brought about in regard to the construction of dams, it would be much better for the builders of such structures, and for the community that would be exposed to the effects of any failure in the judgment of the individual.

With this idea in view, the writer has attempted to find a form of construction that will give a large factor of safety under the most unfavorable conditions that can be assumed; though, it is evident at the start, that so desirable a result can, in most cases, only be obtained at some moderate increase over the cost of the older designs. Many difficulties have to be encountered in the attainment of such an end; but it is an end well worth striving for, and the following suggestions are submitted to the profession for what they are worth.

Hydrostatics, so-called, has only to do with the pressures involved in dam construction; and the resistance against these pressures is purely a matter of statics. There is no difference of opinion as to the laws of statics; but practice does differ widely as to the application of these laws in designing structures to resist hydrostatic pressures. Now, if we assume the triangle as the governing principle of statics, as applied to dams, its de-

*Semple and Boquet Sts., Pittsburg, Pa.

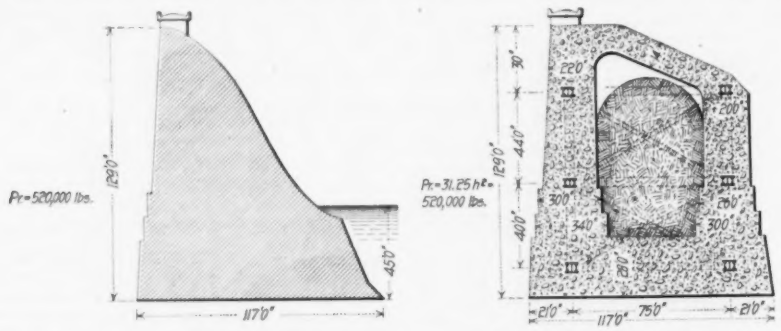
velopment results in the truss; and with a truss formation we bring the dam within the category of structures that we can figure upon with very considerable certainty.

Earlier writers upon this subject held that a dam was a beam, supported against the banks at its ends and uniformly loaded. Recent authorities deny this, and assert that each vertical foot of the dam is a unit which must take care of itself, and is independent of any other part. This latter contention is also incorrect; for, as dams are usually constructed, each vertical foot of wall is intimately joined to the abutting sections, and is affected by the action of its neighbors. If we assume that one vertical foot of a dam is under pressure, and all the other sections are unloaded, this particular piece of loaded wall would have a tendency to more forward a certain amount at the top, diminishing to zero at the bottom—provided, it were free to move at all. The amount of this movement would depend upon the compressibility of the bottom; the height of the structure; the nature of the material, and the nature of the workmanship. This will only be true for each vertical foot of the dam, when all of these conditions are exactly similar; and if the maximum movement at the top of the dam were plotted as a straight line, the section of the dam, at each unit of length, would have to be varied to meet the controlling factors mentioned above. As this latter condition would be an impossibility, the line of movement at the top of the dam would really be represented by an irregular line, or a curve. A uniform forward movement, such as would be represented by a straight line, could not take place without one part having an undue tendency to move forward, being assisted by parts not so affected; and this would give a case of unequal loading.

It is well known in structural design that unequal loading can only be taken care of by the employment of some form of member adapted to the taking up of diagonal stresses, acting in conjunction with components which are at right angles to the line of pressure. In other words, in the dam, there would be a push and a pull in the upper and lower fibers of the wall, and also a diagonal stress—all in a horizontal plane, and for as many horizontal planes as it is convenient to take in the vertical height of the wall. The top of the wall would be most in need of this triangular construction, and the bottom would require the least. The logical conclusion from this theory would be—that the wall should have to be wider at the top; but the requirements against overturning also demand that it be wide at the bottom, and it would seem that there is need for considerable width at all parts of the dam.

It is true, that if the bottom is rock, the compressibility of the bottom may be very small; if the material used in the dam were granite, the compressibility of this material would also be small, and in a lesser degree the effect of varying workmanship may be slight; but the height of the wall is at all times a distinct and powerful factor in determining the resistance to destructive effort. In the case of a foundation inferior to rock, there may be great differences in the ability to resist compression; and where it is impossible to accurately estimate the value of this foundation, it would be well to adopt a form of dam that would be able to transfer portions of this load from weaker to stronger points. Water flowing over the dam would impose an additional loading by its weight and impact; and this further loading will not be uniform because the center of the current will have a greater velocity than other parts, and the position of this center may vary from time to time with floods. In the design, therefore, all of the foregoing conditions have to be carefully studied and provided for; but there is this advantage with the truss formation over older forms. If any one point is loaded to near the breaking point the employment of tensile members in the downstream face, and compressive members in the upstream face, used in conjunction with diagonals, may enable us to transmit a portion of the overload to such parts of the dam as are better bedded, or not so hard pressed by the current.

As to the factor of safety to be assumed, bridges are given a factor ranging from 5 to 10; buildings, from 3½ to 6, and machines, 3 to 10; while dams are generally given a factor of safety ranging from 2 to 3. When the comparative disaster that may follow the breaking of a large dam is considered, this proportioning of the factor of safety seems absurd; and if dams were graded in order of the possible destruction following breaking, the factor of safety might probably reach 20 to 30 in some cases. It would seem better, therefore, to range dams with bridges and give them a safety factor of 5 to 10.




Present Section. Proposed Steel and Concrete Section.

COMPARATIVE CROSS-SECTIONS OF VYRNWY DAM, AND OF PROPOSED STEEL AND CONCRETE DAM FOR THE SAME SITE

The abutment walls of a dam form a very important part of the structure; and if the sides of the valley are solid rock, any means of transferring stress to these abutments would increase the factor of safety without adding especially to the cost. If the banks are of earth or clay, the plan proposed would require the building of special abutments continued upstream to a point of decreased pressure, or one corresponding to the ability of the soil to resist the pressure imposed; and in the case of long dams, intermediate abutment piers might be advisable.

For the purpose of illustration of his theory the writer has taken a dam 60 ft. long and 20 ft. high; there will be a pressure equivalent to 750,000 lbs. at the face of this dam, and the center of this pressure will be 6.6 ft. above the bottom of the dam. It is then assumed that the front wall acts as a vertical beam and transmits the pressure of the water to the top and bottom horizontal trusses. The load on the top truss will be 250,000 lbs., or 62,500 lbs. on each of 4 panels; the load on the bottom truss will be twice as much, or 500,000 lbs. By working out the sections the following estimate of cost is obtained:

| | |
|---|---|
| 30,422 lbs. steel at 3.54 cts. = | $1,064.77 |
| 377 cu. yds. in walls, at $7.00 = | 2,639.00 |
| 200 cu. yds. earth filling at 20 cts. = | 400.00 |
| Total | $4,103.77 |

For a stone dam of the usual gravity section there would be about the same amount of wall, or 377 cu. yds.; and at $10.88 per cubic yard, this would also cost $4,103. But if the stability against sliding or overturning of the new design is compared with the old, we find an advantage for the new design of 20% in resisting sliding, and about 12% in resisting overturning. The new section also rests evenly upon the bed of the stream, and there is no tendency to move forward when the reservoir is empty. The above percentages do not take into account the action of the trusses in transferring a full load to the abutments. The coefficient of sliding on the base of the old design is 46; and that of the new design is 37.5; and if the coefficient of 46 is assumed to give a factor of safety of 2, the factor of the new design will be 5.4, deduced as follows: Taking the concrete at 100 lbs., and the steel at 15,000 lbs. per sq. in., gives a ratio of 150 to 1. Investigation will show that there is an area of wall equal to 300 times the area of the trusses; so that if the walls act as assumed they would carry two full loads to the abutments. The new design would then have:

| | |
|---|---|
| 2 + 20% | 2.40 |
| + strength of truss | 1. |
| + strength of walls | 2. |
| Factor of safety | 5.40 |

In addition to this increased factor of safety, the new structure is designed to carry unequal loading; and if the banks are rock, there will be no expense for abutments, and the above advantages are secured at no additional cost. The stress of 15,000 lbs. per sq. in. is assumed as a proper stress with the purpose of permitting the steel and concrete to act together as nearly as possible. If we wish to increase the safety-factor, this can be done by widening the dam, and making the chords of the truss 12, 14 or 16 ft. apart on centers, instead of 10 ft. The added expense would be a slight increase in cross walls and center filling. In regard to the unequal modulus of elasticity in concrete and steel when under strain, considerable reliance is based upon the published tests of such composite structures in Melan bridges, floors, etc., where the two materials seem to act together. The plan proposed would require that the steel members should be especially designed for this use; all wide surfaces of plates should have holes punched in them, and beams should either have similar holes or angle irons riveted to them; in other words, every precaution should be taken to unite the concrete and the steel members as intimately as possible.

A comparison of the new design as applied to the Vyrnwy dam would result about as follows, reference being had to the three sections given:

| | Sections, I. Vyrnwy Dam. | II. Proposed. | III. Proposed. |
|---|---|---|---|
| Area of wall, sq. ft. | 8,972 | 9,600 | 1,100 |
| Weight per lin. ft., lbs. | 1,288,000 | ..... | ..... |
| Coefficient of friction | 40.30 | 32.7 | 22.6 |
| C. of gravity, abv. foot, ft. | 70.22 | 60.0 | 90.0 |
| Resistance to pressure, lbs. | 90,443,000 | 95,000,000 | 161,000,000 |
| Pressure of water, lbs. | 520,000 | 520,000 | 520,000 |
| Overturning moment, lbs. | 22,360,000 | 22,360,000 | 22,360,000 |
| Estimated cost, pr lin. ft.: | | | |
| At $10 per yd. | $3,320 | ..... | ..... |
| With conc. at $6 pr yd. | ..... | $2,130 | |
| Filling at 20 cts. pr yd. | ..... | 180 | $2,450 |
| Steel trusses | ..... | 1,000 | 1,200 |
| Total | ..... | $3,310 | $3,650 |

In the third section the amount of wall is increased 23% over the Vyrnwy design; but the stability is increased 70% and the coefficient of friction is reduced from 40.3 to 22.6, or nearly one-half.

On generally comparing the truss design with the solid dam of similar outside dimensions, it will be found that the saving effected by substituting cheap filling for concrete in the interior, or neutral portion of the mass, will cover the expenses of the truss. Or, this useless, neutral fiber in the interior is thus converted into steel and placed where it will do most good.

## REASONS FOR THE ADOPTION OF WATER-TUBE BOILERS IN THE U. S. NAVY.*

By Admiral Geo. W. Melville, Engineer-in-Chief, U. S. N.

The task I have set myself is to show that the decision to use nothing but water-tube boilers in our future war vessels is a step in advance, and that it is a natural step towards the evolution of the perfect fighting machine. I desire to show that it is no radical change, and that it does not involve the use of anything but a tried, successful, and reliable apparatus that gives us positive and great advantages over the character of boilers heretofore generally used. I desire not to minimize the disadvantages following this change, but to show that these disadvantages are not only not insurmountable, but, for warships, they have already been overcome.

In the first place, I want to state that water-tube boilers are bad in principle. They carry the pressure inside their

*Abstract of a paper read at the seventh general meeting of the Society of Naval Architects and Marine Engineers, held in New York, Nov. 16 and 17, 1899.

weakest parts—the tubes. A failure in a tube is followed by the opening of a fault, sometimes to a dangerous degree. In a fire-tubular boiler, on the contrary, the pressure would continue to close a split tube. It is true that a failure of a boiler tube generally comes from pitting, where fire-tubular boilers generally have such a great advantage as in cases of split tubes. Yet failure of tubes is the most common defect in all boilers, and a proper design would place the pressure on the outside of the tube. Water-tube boilers are, from their very definition, designed from a wrong principle, not only because of the direction of application of pressure upon the tubes, but also on account of the decreased amount of water in the boiler, of the increased difficulty of observing a leak, and of the decreased value of heating surface in water-tube boilers. For this reason, as an engineer, it is with some misgiving that I state that I consider water-tube boilers tactical necessities for warships.

Builders of water-tube boilers use solid-drawn tubes almost exclusively for marine work. This, of course, decreases the danger of split tubes, but it does not change the mechanical principle. Some day, probably not in my time, we may hope to have a boiler having fire tubes and having the advantage of water-tube boilers. Such a boiler would force its way at once into all navies, just as water-tube boilers are doing at the present day.

Disbelieving, as I do, in the cardinal principles of water-tube boilers, I have sturdily opposed their adoption by our Navy until now I am convinced that they must be used if we are not going to content ourselves with inferior ships to those built for other nations. Of course, during the period of development of the design of water-tube boilers, that even now continues, I have, in my official capacity, kept track of and taken part in the world-wide experiments with their use. Water-tube boilers have advantages and I have never been blind to them. Two years ago I stated that their disadvantages had been sufficiently removed to justify their use on our warships. Now I consider that the value of their advantages has been sufficiently developed to necessitate their use if we do not wish to be left behind in naval design.

The principal thing to which I desire to call your attention is the fact that all vessels are essentially compromises. Any ship must be considered in its entirety, and the advisability of a change in design of any part must be determined from its effect upon the ship as a whole. Whether or not water-tube boilers are superior to cylindrical boilers as boilers simply, if there be a beneficial effect upon the ship as a whole due to the adoption of water-tube boilers, these boilers are essential to the best design.

The necessity of compromise in ship design must be self-evident to the members of this Society who have the problem before them for solution almost daily. Taking the particular case of warships, the size of our ships is limited by their draft. We are building vessels now that are as large as any that can enter our harbors and docks, and we cannot, therefore, increase their power as fighting ships except by improvements in design. Any increase in weight allotted to one essential of the efficiency of the ship must be counter-balanced by a decrease in some other perhaps equally essential element. So far, this has most frequently been done by robbing the coal pile—an extra gun, a half knot in speed, or an additional inch in armor protection—each mean a few tons less coal in the bunkers. I must except the more recent designs of battleships from the above general rules. The importance of coal endurance has become more and more manifest, and it has been appreciated fully in our recent designs. Incidentally, these last ships are fitted with water-tube boilers.

Water-tube boilers are considerably lighter than those of the old type, and their effect upon ship design may be given as follows: Of two ships, having all other qualities identical, one fitted with cylindrical boilers and the other with water-tube boilers, the latter will be somewhat the smaller and handier—will have somewhat less draft, and will cost less.

Limited, as we are, in the size of our warships by their draft, I think that the foregoing shows that for a maximum of fighting efficiency we must use water-tube boilers. The designing engineers of our naval vessels are limited in weight and space. They save little or nothing in space perhaps, but they save greatly in weight if they adopt water-tube boilers. If these can be successfully operated on shipboard they must be used because of their decreased weight. The foregoing is entirely apart from any consideration of the relative merits of water-tube and fire-tubular boilers, but it is conditional upon the possibility of the successful operation of water-tube boilers.

Before considering claimed advantages and disadvantages of water-tube boilers, I desire to give a few historical facts, most of them already well known to the members of this Society.

The old Martin boiler was the first water-tube boiler ever used in any naval vessel. We had good success with these boilers, but they died out of use with the introduction of high-pressure multiple-expansion engines and the consequent cylindrical boilers.

For years none but water-tube boilers have been installed in our steam launches. These have always been attended by unskilled labor, yet the results have been very satisfactory. Some accidents have occurred, but they have been very few, probably no greater in number than if fire-tubular boilers had been used, and it is to be noted that the results of a boiler explosion would probably have been worse in almost every case if the failure had occurred in a fire-tubular boiler.

Torpedo-boats and destroyers in our Navy have always, since the time of the "Cushing," been equipped with water-tube boilers of various types. Small bent tube boilers have generally been used. There have been some cases of sad accidents in the fire-rooms, generally due to carelessness in manufacture, and particularly in tube setting, but not to defective design. The boilers have proved to be quite as reliable as the extremely light engines of these boats. With the small amount of skilled attention it is possible to give torpedo-boats, and considering the character of service demanded of these small craft, I think that no engineer will to-day question that the use of light water-tube boilers, with the higher speeds possible as a result, adds to their efficiency and security. I think even Herr Schichau has come to be of this opinion.

The first large installation of water-tube boilers in our Navy was on the "Monterey." Indeed, at the time, this was the largest installation of water-tube boilers in any navy. In this monitor, as you all know, there are four round Ward water-tube boilers, with two cylindrical single-ended fire-tubular boilers. The water-tube boilers have been satisfactory. It is worthy of note that there has been very little difficulty experienced in maintaining a steady water level, although the boilers have a very small amount of contained water. Tubes have failed by pitting several times, though never with any danger to the firemen. The water-tube boilers have been twice retubed by the ship's force without laying the ship up at any navy yard. On one occasion, probably with a view to thoroughly testing the water-tube boilers, or to satisfy the unholy desires of some person decrying water-tube boilers, the ship made a voyage of about 8,000 knots, largely under forced draft, and, whenever possible, with all boilers in use. There was no resultant injury to the water-tube boilers, which performed well throughout the trial. The combustion chambers of the cylindrical boilers came out of the trial badly bulged.

The Yarrow boilers of the "Nashville" have operated fairly successfully, though they cannot be said to be completely satisfactory on account of the amount of trouble given by bulging of drums and by leaky tubes. The first set of copper tubes has been replaced by others of steel to considerable advantage. I believe that the latest designs of this type of boiler provide for the use of slightly curved tubes next the fire. This ought to be advantageous.

The "Marietta's" trip around South America, at the beginning of the war with Spain, was quite as successful as was that of the "Oregon." The first ship is fitted with Babcock & Wilcox boilers, the second with cylindrical boilers. No repairs were required to either set of boilers after the completion of the trip.

The "Annapolis" is also equipped with Babcock & Wilcox boilers, and here, as on the "Marietta," these boilers have been thoroughly successful. Indeed, a former chief engineer of the "Annapolis" has stated to me that the boilers of that ship were easier to manage in use and easier to maintain in a state of high efficiency than are cylindrical boilers.

The "Chicago" has several Babcock & Wilcox boilers, and these have so far worked in a thoroughly satisfactory manner, no failure being reported under any circumstances.

The foregoing represents the tried installations of water-tube boilers in ships larger than torpedo-boats and destroyers in the United States Navy. Babcock & Wilcox boilers of the shore or stationary type were installed in the old monitors "Canonicus," "Mahopac" and "Manhattan," the old rectangular boilers being entirely worn out and it being deemed advisable to fit these old boats for whatever service they could do. The change was commenced at the beginning of the Spanish war. Before its close the change was complete and a somewhat greater speed was attained than with the original boilers. This change was made without injuring the decks of the monitors. The old boilers were cut up and passed out through the smokestack, down which the parts of the new boilers were passed, the latter being assembled in the engine-room space. This is an instance where none but water-tube boilers could have been used, and where every facility of repair and installation was of enormous advantage. For naval vessels with their protective decks the facility with which water-tube boilers can be removed or completely renewed without disturbing the decks may, of itself, justify us in adopting water-tube boilers.

There are building and repairing several other ships of our navy to be fitted with partial or complete outfits of water-tube boilers. These include the "Alert," "Atlanta," "Cincinnati," "Wyoming" (Babcock & Wilcox), "Maine" and "Connecticut" (Niclausse), "Missouri," "Wisconsin," and "Arkansas" (Thornycroft), and "Florida" (modified Normand).

The foregoing gives the installation of water-tube boilers in our navy from which data has been obtained. So far as tried the boilers have invariably been easy of operation, though I have found more skill required to obtain the best results from these boilers than would have been necessary if cylindrical boilers had been used. Particular attention has been given, in all cases, to the feed arrangements. Water-tube boilers must have ample feed pumps, and the regulation of the feed must be easy. At first the heating surface of water-tube boilers was made 3 sq. ft. per horse-power against 2 sq. ft. necessary with cylindrical boilers. This figure has been gradually reduced until now we are down to 2.4 sq. ft. of heating surface per horse-power, about as low as I think it is yet safe to go with water-tube boilers.

The economical results from water-tube boilers were at first not particularly good. At present we get quite as good results from water-tube boilers of the latest design as from the best cylindrical boilers. The ratio of heating surface to grate surface has been kept up to at least 40, although we do not yet feel warranted in allowing as small grate surfaces in water-tube boilers as in cylindrical boilers. Water-tube boilers lose in efficiency when forced, especially those of the straight-tube type. Of course, this is not of very great moment to us in a naval vessel which is under forced draft only at maximum speed, but it is nevertheless a disadvantage.

The following table shows the relative economy of cylindrical and water-tube boilers:

| | Displacement, tons. | Knots per ton coal, most economical speed. | Number of screws. | Grate surface, sq. ft. | Heating surface, sq. ft. |
|---|---|---|---|---|---|
| *"Annapolis" | 1,000 | 26.38 | 1 | 98 | 3,820 |
| *"Marietta" | 1,000 | 22.27 | 2 | 94 | 3,664 |
| †"Newport" | 1,000 | 18 | 1 | 78 | 2,524 |
| †"Princeton" | 1,000 | 19.6 | 1 | 78 | 2,524 |
| †"Vicksburg" | 1,000 | 21.25 | 1 | 78 | 2,524 |
| †"Wheeling" | 1,000 | 16.6 | 2 | 60 | 2,508 |

*2 B. & W. boilers. †2 single-ended cylindrical boilers.

The increased grate surface we have required with water-tube boilers will be a positive advantage to our ships' steaming qualities. I consider that sustained sea speed depends largely upon the grate surface. Heating surface, of course, must be provided, but I should prefer an excess of grate surface to an exceedingly high ratio of heating surface to grate.

Up to this time we have had no trouble from salt water or grease in water-tube boilers. Indeed, we could hardly be more troubled by salt water with this type of boiler than we have been with cylindrical boilers. We suffered severely in our short war with Spain from dropped furnaces in cylindrical boilers. I do not think that a properly designed water-tube boiler will give more trouble from the use of impure feed water, such as sometimes we must have at sea, than any other boiler. I do not think tubes more liable than furnaces to fall from a deposit of scale. In any event, the evaporating plants of all our ships are being made adequate to give fresh feed water. The only danger of salt water in the future should come from leaky condensers.

Glancing abroad, for a moment, we find every modern naval power, from England to Japan, committed to the use of water-tube boilers on the largest scale. Each of these countries has had its experience, and each has decided not only that water-tube boilers can be worked, but also that they work well and that they must be used in naval vessels.

I will give a few observations on the working of various types of water-tube boilers abroad. The result of a first glance would seem to be that anything would do to make steam, from Watt's tea-kettle to the most complicated of modern steam generators. I know of one French boiler (you know what ingenious mechanics the French are) composed equally of water and fire tubes. The tubes were concentric and the distance between them but one millimeter. Of course, the amount of water is very small—so small as to put this boiler in the class called by their originators "inexplosible." This boiler was tried at the works of the maker with good results. It was next tried in a torpedo-boat with equally remarkable results—7 men killed, I believe.

We have read of explosions, however, of really well-designed water-tube boilers. Generally it is found that a tube had failed and that the furnace door was open—the result, more or less fatal burns to all in the fire-room. We hear of all the failures, but the successes are never mentioned. It is not difficult to foresee the failure of a boiler plant designed to furnish 120,000 lbs. of steam per hour but regularly required to furnish 160,000 lbs. per hour. If nothing else fails the feed pumps will not do the work and the tubes will, of course, be burnt out. This would happen with any type of boiler.

You see, I harp on the failures, for I find I can glean the most information from them. Many of the failures have come from the use of boilers that were inaccessible for cleaning and repairs; others from faulty design; others from poor workmanship; others, again, from neglect. Water-tube boilers require skilled attendance. Other boilers have failed from poor material; others from failure of the feed pumps; but there is not one, so far as I know, that can properly be said to have failed purely as a result of being a water-tube boiler. Failures may come from misusing water-tube boilers but not from using them. I consider that the experience of the last ten years or more in our own and in foreign navies justifies me in stating that water-tube boilers, when proper precautions are used,

can be successfully adopted for the steam generating plant of ocean-going vessels. They are necessities to the best design of warships.

I would naturally come now to a discussion of the claims of the adherents and opponents of water-tube boilers. You have all heard these arguments and it seems almost useless to go over them. I shall simply state what I believe to be the advantages and disadvantages of water-tube boilers compared with cylindrical boilers.

Advantages.—Less weight of water; quicker steamers; quicker response to change in amount of steam required; greater freedom of expansion; higher cruising speed; more perfect circulation; adaptability to high pressures; smaller steam pipes and fittings; greater ease of repair; greater ease of installation; greater elasticity of design; less danger from explosion.

Disadvantages.—Greater danger from failure of tubes; better feed arrangements necessary; greater skill required in management; units too small; greater grate surface and heating surface required; less reserve in form of water in boiler; large number of parts; tubes difficult of access; large number of joints; more danger of priming.

A saving in space has been claimed for water-tube boilers, but I do not find this claim sound when account is taken of the increase in grate and heating surface necessary in water-tube boilers to ensure satisfactory working, and because of small units the space for accessibility is increased rather than diminished.

The fact that water-tube boilers raise steam quickly is of the greatest advantage. I have stated elsewhere that I consider the battle of Santiago to have developed the necessity of the use of water-tube boilers whether it taught us anything else or not. It would have been of the greatest advantage to have had, during the blockade of Santiago, boilers capable of raising steam in less than half an hour. Coal need not have been used to keep all the boilers under steam all the time. The "Massachusetts" might have shared in the glories of the fight if she had been fitted with water-tube boilers. The "Indiana" would have kept up with the "Oregon" and the "Texas." The "New York" would have developed at least three knots more speed and the Navy would have been spared a controversy. I think the "Colon" would not have gotten as far away as she did. But we did not have the water-tube boilers.

The higher pressures possible with water-tube boilers give us smaller and safer steam pipes and better valves. It decreases the size of the fittings and the difficulty of tracing the labyrinth of a ship's piping. It increases the efficiency of the engines. The introduction of compound engines forced us to use cylindrical boilers. In the same way the use of quadruple expansion engines necessitates, for economy, the use of water-tube boilers.

But the quick steam raiser is, because of that very fact, not so safe as its predecessor. Of course, nothing on a man-of-war is very safe in war times, but we want things as safe as possible, and the boilers are the keys to the situation in the modern battleship. I think that safety in handling water-tube boilers may be assured by using skill in the fire-rooms. I have more than ten years' successful experience with water-tube boilers on which to found this opinion, and I submit that the boilers, placed as they are behind the heaviest armor and below the thick protective deck, are, at the worst, the safest apparatus on a battleship. If we can make them work well we would do wrong to refuse to use water-tube boilers on our ships.

For merchant and for yacht practice it is a different question. I was recently asked what boilers to use in a large steam yacht. I recommended cylindrical boilers. For merchant work the boilers are always in use developing a fixed power. Weight is not there so important as in warships, and I think it is at best a moot question whether cylindrical boilers are not still the best that can be fitted in ocean-going merchantmen. In some cases where there are short trips and the opportunities for repair must be gotten during the very short lay-ups at the end of the route, the quick steam raising qualities of water-tube boilers, with their freedom of expansion, enables blowing down the boiler immediately on arrival in port and still having steam at an hour's notice on all boilers. Such cases as this seem to me to demand water-tube boilers.

As to the type of boiler to be used, there are as many to choose from as there are fleas on a dog. Some one has said that a certain amount of fleas keep a dog from brooding over being a dog. So the number of varieties we have to choose from may be a good thing for all.

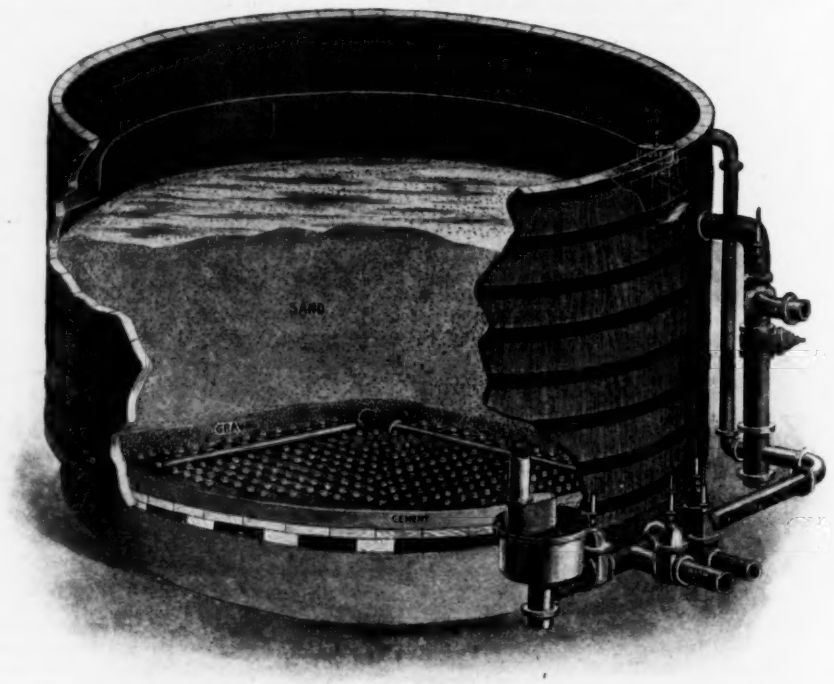
I have always opposed the use of boilers containing screw joints in contact with the fire, and have attempted to secure boilers having no cast metal in the pressure parts. Cast steel is not yet good enough to put between 300 lbs. of steam and our firemen. I believe in straight tube boilers as being easier of examination and repair than bent tube boilers. I believe in large tube boilers for the same reason and because the tubes are thicker and have more margin for corrosion. I believe in boilers having as few joints as possible. Water-tube boilers must have freedom of expansion of the various parts, and the simpler the boiler the better. It should not be necessary to introdue reducing valves between the boilers and the engines to secure a steady steam pressure at the latter, nor should it be necessary to have automatic feed arrangements to ensure steady water level in the boilers. To be successful a boiler must be easy of repair. Lightness is a natural attribute of all water-tube boilers, but it is not wise to go too far in this direction. The ratio of grate surface to fire surface occupied for the complete boiler plant must be as large as possible. The units should be large, the grates short and not too wide. The passage of gases through the tubes should be sufficiently long to ensure economy. These gases should be well mixed before entering the spaces between the tubes for the same reason and to prevent smoke. The circulation of the water in the boiler must be free. Tubes should not be too long and the fire-rooms must always be sufficiently wide to provide for free withdrawal.

The foregoing is what we want. We have most of the above desiderata in several well-known types of boilers, and ultimately we shall discover the value of each of the foregoing points, and then it will be possible to differentiate between the various types more perfectly than we now can.

In the meantime, all that I have to say is that the use of water-tube boilers has been definitely decided upon for our naval vessels, because water-tube boilers give tactical advantages of great moment, and because, with care in the selection, manufacture, and management of water-tube boilers, other disadvantages may be neutralized.

## BACTERIAL TEST OF A MECHANICAL FILTER AT LOUISIANA, MO.

We give below the results of a bacterial test of a mechanical filter which is treating water drawn from the Mississippi River, at Louisiana, Mo. The water-works at this place were built in 1887-8, by the Louisiana Water Co., which is controlled by the American Water-Works & Guarantee Co., of Pittsburg, Pa. Since the plant was constructed mechanical filters have been added, and the original filtering capacity has been increased twice.




GRAVITY MECHANICAL FILTER AT LOUISIANA, MO.
Continental Filter Co., Contractors.

The original filters and first addition were built under patents now controlled by the New York Filter Manufacturing Co. The addition this year was made by the Continental Filter Co., 35 Wall St., New York city, to whom we are indebted for the information given in this article.

The new filter has a guaranteed capacity of 500,000 gallons in 24 hours. It is supplemented by sedimentation tanks having an effective capacity of 28,000 gallons, giving a normal subsidence of 108 minutes. The filter is of the gravity type, a bed of graded sand 3 ft. deep and 176.6 ft. in surface area, being placed in a tank 15 ft. in diameter. The general design of the filter is shown by the accompanying illustration. Filtered water and air are used alternately in washing the filter, the entire process of washing, the company reports show, taking 20 minutes of time and a volume of water equal to 2% of the daily capacity of the filter. The air is designed to ensure thorough agitation of the sand and to prevent caking, no rake being used for the purpose. Sulphate of alumina is used as a coagulant, varied in amount in accordance with the character of the water, and supplemented with lime at times of low alkalinity, in order to ensure perfect coagulation.

Further particulars regarding the plant are given in the following report on a test of the plant. The report is dated Oct. 3, 1899, and was made by Mr. Wm. H. Rush, who made the test under direction of Dr. Amand Ravold, Professor of Bacteriology and Hygiene, in the Medical Department of Washington University, St. Louis. The report in full is as follows:

The filter plant at Louisiana is situated adjacent the pumping station, on the west bank of the Mississippi River, near the upper limit of the city. It comprises a low-service and high-service pump, two filters of older model, and a 500,000-gallon Continental filter, with sedimentation tanks and accessory appliances recently constructed by the Continental Filter Co., and operated as a part of their system. The examination herein detailed related to the latter filter alone, and had for its principal aim the determination of the bacterial efficiency of that filter. The examination began at noon Monday, Sept. 18, and ended at 6 p. m., Saturday, Sept. 23. During this time samples of the river water and effluent were taken at intervals of six hours and three hours respectively, thus affording opportunity for the observation of the operation of the filter for an uninterrupted period of about 5½ days.

The water is drawn from the river by means of a suction pipe, which opens 85 ft. from the shore, and is elevated to the sedimentation tanks by the low-service pump. The coagulants, aluminum sulphate and lime, are introduced into the water before it enters the sedimentation tanks. During the present test the average amount of chemicals used was 2.5 net grains of sulphate of alumina, and 1.25 net grains of lime per gallon.

The sedimentation tanks, of which there are two, and used alternately, are 20 ft. in diameter and 16 ft. deep, with an effective depth of 12 ft., 3 ft. being allowed for deposition of mud. They are operated on the fill, quiescent subsidence and draw principle, filling and emptying being controlled by a system of valves operated automatically by hydrostatic pressure.

Water enters and leaves the sedimentation tanks through a 12-in. floating pipe, which swings freely around a swivel elbow at the base of the tank, and is provided with a float at its free end. The pipe thus rises and falls as the tank fills and empties, the free-end being maintained constantly at the surface of the water in the tank. As the process of emptying a tank requires about 51 minutes longer than that of filling, there is a period of this length during which the water undergoes quiescent subsidence. During this sedimentation the larger part (more than 60%, I am told by the operators) of the suspended matter is removed, and is washed periodically into the sewer.

The water flows from the sedimentation tank into the filter tank, entering the latter through a system of horizontal 6-in. pipes perforated above at intervals of 6 ins. by 1-in. holes, so that it is distributed uniformly over the entire filter. It passes by gravitation through the filter, a 3-ft. layer of sand, being collected by an extensive underdrain and straining system, and flows thence into the clear well, from which it is pumped into the reservoir or is distributed directly to the city by means of the high-service pump.

Once in about 12 hours the filter is washed. This is accomplished by means of reverse currents of air and water. First a current of air is driven through the sand layer by a rotary air blower, and this is followed by a current of water from the reservoir. Aeration and washing are then repeated, each process occupying 2 and 3 minutes respectively. The wash water and accumulated mud are drained off into the sewer.

During the present examination the Continental filter furnished the entire water supply of the city, 500,000 gallons per day, until Thursday, 3 p. m., after which 600,000 gallons per day were used, the additional 100,000 gallons being supplied by one of the other filters. Throughout the test the filter was operated in the normal manner, except as to the chemicals, a somewhat larger amount of which was used than would ordinarily be required at this location.

The test had been preceded by a considerable period of dry weather and consequently at the beginning the water of the river was low and comparatively free from suspended matter. On Sept. 17, however, the day preceding the first observations, much rain fell in the region of Louisiana, and in the region lying to the northwest, territory drained by Salt River, a stream flowing into the Mississippi about two miles above the pumping station. This rain greatly increased temporarily the suspended matter in the water of the river, and increased surprisingly the number of bacteria. The effect of this rise in the river could be seen by 6 o'clock the next day (see table), and continued several hours. After this the water assumed approximately its former condition. The effluent throughout the test, except for a brief period during which the plant was operated without the presence of any representative of the filter company, was beautifully clear and sparkling.

The bacteriological work was carried on in the waterworks laboratory, in Louisiana. Samples of water for bacterial examination were collected by myself or according to my directions in sterilized bottles at the pumping station, those of the river water being drawn from the suction pipe near the pump, before the introduction of the coagulant, and those of the effluent from the pipe leading from the filter to the clear well. Samples were usually plated out morning and evening, those collected in the meantime being kept on ice at the filter plant.

In the preparation of the culture medium a bouillon was made from Liebig's beef extract, of strength corresponding to that obtained by extracting 500 gr. of lean beef with 1,000 cu. cm. of water. To this bouillon was added 10% of gelatine, 1% of Witte's peptone, and 5% of sodium chloride, C. P. The acidity of the medium ready for use was 1.3%. The medium when complete was transferred to test tubes and sterilized at 100° three times on successive days. The sterilization proved to be perfect, and the medium was clear and light colored. One dozen tubes of medium furnished me from the laboratory of Dr. Ravold, acidity 1.5%, were used side by side with these, and no difference of growth was discernible.

In making cultures of the effluent 1 cu, cm. of the latter was plated directely. The river water was diluted to one-tenth, by adding 1 cu. cm. of the sample to 9 cu. cm. of sterilized water in a test tube and plating 1 cu. cm. of the mixture. The cultures were placed for development in two small ice chests, in which the temperature was maintained with considerable uniformity at 19°. On two occasions, once near the beginning and again near the end of the test, the temperature in one or other of the chests fell for a few hours to 17° or 15°, but never rose above 20°.

Plates were counted out whenever the stage of development indicated danger of loss from liquefaction, and this was as a rule after a period of growth of 55 to 60 hours. A uniform temperature of 20° brought the cultures to maturity often in 48 hours, whereas a low temperature retarded the development and prolonged the time between plating and counting in some instances to 72 hours.

Two samples of the effluent contaminated and were discarded. One plate was destroyed by accident, and one liquefied within 24 hours. From 9 p. m. Wednesday, to 4 a. m. Thursday, the filter was shut down owing to repairs on the main. With these exceptions the appended tables shows the conditions of the water at the stated intervals throughout the test.

In order to test the efficacy of washing the filter for the removal of the accumulated bacteria in the sand, and also to obtain an idea of the distribution of bacteria in the different depths of the sand before washing, specimens were taken from the sand at depths of 1, 6 and 12 ins., just before the last wash on Saturday, and from the surface immediately after washing. The samples of the unwashed sand, depths as above mentioned, showed 118,000, 6,000 and 400 bacteria per grain, respectively. One grain of the surface sand after washing showed 2,300. Owing to lack of laboratory facilities these observations could not be repeated. A comparison of the two superficial samples shows the percentage of removal to be 98.

Bacterial Test of Mechanical Water Filter at Louisiana, Mo.

| No. of run. | Samples collected—Day. | Hour. | Bacteria per cu.cm.—Separate counts—River. | Effluent. | Averages | | Bacterial efficiency per c't. removed. |
|---|---|---|---|---|---|---|---|
| 1. | Sept. 18 | 12 m... | 1,700 | 31 | 17,400 | 40 | 99.8 |
| | | 3 p. m. | ..... | 46 | | | |
| | | 6 " | 8,500 | 50 | | | |
| | | 9 " | ..... | 46 | | | |
| | | 12 " | 42,000 | 36 | | | |
| 2. | Sept. 19 | 3 a. m. | ..... | 56 | 57,000 | 72 | 99.9 |
| | | 6 " | 57,000 | 86 | | | |
| | | 9 " | ..... | .. | | | |
| 3. | Sept. 19 | 12 m... | 1,600 | 56 | 1,800 | 36 | 98.0 |
| | | 3 p. m. | ..... | 44 | | | |
| | | 6 " | 2,100 | 37 | | | |
| | | 9 " | ..... | 22 | | | |
| | | 12 " | 1,700 | 23 | | | |
| 4. | Sept. 20 | 3 a. m. | ..... | 43 | 4,300 | 49 | 98.9 |
| | | 6 " | 1,600 | 44 | | | |
| | | 9 " | ..... | .. | | | |
| | | 12 m... | 7,000 | 60 | | | |
| 5. | Sept. 20 | 3 p. m. | ..... | .. | 1,700 | 58 | 96.6 |
| | | 6 " | 1,200 | 58 | | | |
| | | 9 " | ..... | .. | | | |
| | | 12 " | 2,200 | .. | | | |
| 6. | Sept. 21 | 3 a. m. | ..... | .. | 1,430 | 43 | 97.0 |
| | | 6 " | 960 | 47 | | | |
| | | 9 " | ..... | 13 | | | |
| | | 12 m... | 1,900 | 68 | | | |
| 7. | Sept. 21 | 3 p. m. | ..... | 57 | 1,175 | 42 | 96.5 |
| | | 6 " | 1,900 | 56 | | | |
| | | 9 " | ..... | 31 | | | |
| | | 12 " | 450 | 24 | | | |
| 8. | Sept. 22 | 3 a. m. | ..... | 53 | 1,400 | 41 | 97.0 |
| | | 6 " | 1,900 | 56 | | | |
| | | 9 " | ..... | 21 | | | |
| | | 12 m... | 900 | 34 | | | |
| 9. | Sept. 22 | 3 p. m. | ..... | 39 | 1,000 | 52 | 94.8 |
| | | 6 " | 1,000 | 63 | | | |
| | | 9 " | ..... | 54 | | | |
| | Sept. 22 | 12 " | 700 | 41 | | | |
| 10. | " 23 | 3 a. m. | ..... | .. | 834 | 45 | 95.0 |
| | " 23 | 6 " | 400 | 23 | | | |
| | | 9 " | ..... | 54 | | | |
| 11. | Sept. 23 | 12 m... | 1,400 | 61 | 1,600 | 48 | 97.0 |
| | | 3 p. m. | ..... | 50 | | | |
| | | 6 " | 1,600 | 47 | | | |
| Average for entire week ..... | | | | | | | 97.3 |

## NOTES FROM THE ENGINEERING SCHOOLS.

Cornell University.—The following non-resident lecturers on engineering subjects are announced: "Evolution of Electric Energy," by Prof. Houston, Dec. 1; "Power Production," by William Kent, Dec. 15; "New Westinghouse Gas Engine," by H. E. Longwell, Jan. 12; "Electrical Engineering Experiences," by A. E. Kennelly, Jan. 19; "Safe Current Transmission," by C. J. Field, Jan. 26; "Three-Phase Railway Work," by W. B. Potter, Feb. 23; "Special Work in Electrical Engineering," by Elihu Thompson, April 13; "Dynamo and Engine Construction," by E. W. Price, Jr., April 27; "Recent Engineering Practice," by W. M. McFarland, May 4. On Nov. 3 a lecture on "The Compression and Liquefaction of Air" was delivered by Mr. Jno. J. Swann, of the Ingersoll-Sergeant Drill Co.

The report of the president for the year 1898-99 to the Board of Trustees is published, dated Oct. 31, 1899. Dr. Schurman reports with the acting president, Professor Crane, who took charge of the administration during the absence of the former in the Philippines, and appends the annual reports of the deans of the various colleges. During the year the college of forestry has been organized, and also departments of hydraulic and of railway mechanical engineering. The roll for the year contained 2,543 names of students in all grades and all departments. The largest attendance was reported as 631, in the academic department, and the next highest, 501 undergraduates, in Sibley College of Mechanical Engineering. The College of Civil Engineering had expected to experience temporary loss in registration through the sudden and radical elevation of entrance requirements to include the higher mathematics; but the registration was 185, as against 122 four years ago. The reduction in numbers at entrance was more than compensated by accessions in the upper classes from other institutions. The great hydraulic laboratory of this college is engaged in the experimental investigation of important problems for the U. S. Deep Waterways Commission. A full program for the next five years is in hand. The Sibley College of Mechanical Engineering enrolled 40 college graduates among the 501 students, candidates for its first degree, a large increase in both figures.

Purdue University.—Mr. Calvin W. Rice, electrician for the New York Consolidated Telegraph and Electrical Subway Co., and the New York Gas and Electric Light, Heat and Power Co., will visit the university on Nov. 15, and lecture before the students of electrical engineering on "The Development of High Tension Service."

University of Pennsylvania.—Mr. C. H. Greenwood (Worcester, '97), who has been connected with the Atlas Tack Co., of Taunton, Mass., has been appointed Instructor in Mechanical Engineering.

University of Michigan.—A course in marine engineering and naval architecture has been established at the university. It will be a graduate course, requiring five years' residence, of which the first 3½ years will be the same as those in the regular engineering courses. At the end of the fourth year the student receives the degree of B. S., and at the end of the fifth year, M. S. The regents have voted $2,000 for the work. Of this, $1,600 is for the salary of an assistant professor in marine engineering. The course will commence with the second semester of the present college year.

A Deering rotary engine of about 25 HP. has been received at the mechanical laboratory for experimental purposes. It will be tested to ascertain the conditions under which it can be most successfully run, and whether it can possibly be made a commercial success.

John R. Allen, Jr. M. Am. Soc. M. E., has been promoted from Instructor to Assistant Professor of Mechanical Engineering.

Professor M. E. Cooley, of the mechanical engineering department, has designed an apparatus for testing thermometers up to a temperature of about 500° F., which is now being constructed. A device of his design is also being made which will be used for measuring the velocity of water moving through pipes and radiators in a hot water heating system. It will determine the frictional resistance of the pipe, elbows and valves.

University of Illinois.—At a recent conference between the Department of Railway Engineering and Mr. J. A. Barnard, General Manager of the P. & E. Division of the C., C., C. & St. L. R. R., the following schedule of tests was arranged for the ensuing year:

1. Calibration of the oil dynamometer. 2. Train resistances with "empties," or the relation between the resistance of "loads" and "empties" to be determined on a level, on curves and on grades. 3. Comparative fuel economy of the 'consolidation" and "ten-wheel" locomotive, and the comparative value of different fuels. 4. Installation and experiments with track inspection apparatus. 5. Examination of water supply apparatus to determine cost to pump 1,000 gallons at various tanks. 6. Examination of valve gear of some type of locomotive, making an attempt to improve the economy by a more satisfactory steam distribution.

The mechanical engineering department, at the request of Westinghouse, Church, Kerr & Co., has arranged to conduct a series of tests of Iowa coal on the mechanical stokers in the central heating station.

AN AMERICAN EXPOSITION IN RUSSIA has been proposed by Secretary of the Interior E. A. Hitchcock, and late embassador to St. Petersburg. The plan is to remove the American exhibits, after the Paris Exposition of 1900 is closed, to either Moscow or St. Petersburg, and the majority of the exhibitors favor the scheme. Congress will be asked to assist, and at least to defray the cost of a commodious exposition building. The Russian authorities express the most cordial support of the proposition. They will admit exhibits in bond, subject to a refund of duty if not sold. They also pledge the actual cost of transportation over Russian lines to the place of destination. Other expenses than these will be paid by the exhibitors. Secretary Hitchcock thinks that there is no better field for a marvelous increase in marketing our manufactures than Russia.

PAPER DRIVING ROPES are being made by the Ironmongers' Rope Works, Wolverhampton, England. The rope is made from twisted strips of pulp paper, laid up finally into a 3-strand rope by ordinary methods, and treated with boiled oil, making it practically waterproof. The actual tensile strength is far less than Manila rope; but for driving purposes it is abundantly strong. At the works, one 1⅝-in. diameter paper rope transmits 6 HP. and runs at a speed of 700 ft. per minute. It has been running since last February, and, it is stated, shows no sign of wear whatever; having merely become polished and smooth. This rope can be spliced like any other rope, though a longer splice is used. It is very pliable and it is lighter than Manila rope.

# ENGINEERING NEWS
AND
## AMERICAN RAILWAY JOURNAL.

*Entered at the New York Post-Office as Second-Class Matter.*
*Published every Thursday*
*at St. Paul Building, 220 Broadway, New York, by*
*THE ENGINEERING NEWS PUBLISHING COMPANY*

GEO. H. FROST, - - - - - - - - PRESIDENT.
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ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston,
C. F. WALKER, Cleveland, } ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 299 DEVONSHIRE ST.
CLEVELAND OFFICE, OSBORN BUILDING.
LONDON OFFICE, EFFINGHAM HOUSE, 1 ARUNDEL ST., STRAND.

*SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current year, 15 cents.*

*In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 329 means that subscription is paid to the 32d week (that is the issue of Aug. 10) of the year 1899; the change of these figures is the only receipt sent, unless by special request.*

*ADVERTISING RATES: 20 cents a line. Want notices, special rates, see page XXII. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.*

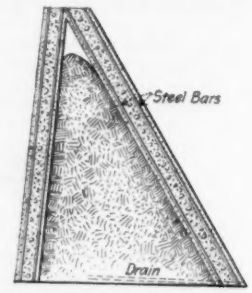

Building operations in Chicago are being seriously interfered with by the actions of the union labor organizations, which for some time past have been getting wages raised, reducing the amount of work which they permit the men to do, and enforcing various arbitrary demands by means of strikes. These strikes are ordered over various small difficulties, and are extended by "sympathetic" strikes, causing continual delay and annoyance in the execution of work. The unions have laid down rules and regulations as to the amount of work which a man may do in a day, and if he does any more he is liable to a heavy fine. The specified amount of work is considerably below what a man could do in a fair day's work, the avowed intention being to distribute the work among a greater number of men, the daily pay remaining the same. A meeting of architects, contractors and real estate dealers, called by the Chicago Architects' Business Association, was held on Nov. 7, to consider the matter, and a number of cases were cited showing the lengths to which the labor organizations are carrying their demands, and the steps which they are taking to enforce them. Mr. W. L. B. Jenney, of Jenney & Mundie, stated that the unions have stopped the use of machinery in the manufacture of cut stone, but with the result that the work has become so expensive that contractors are using terra cotta instead of cut stone. He also stated that the unions are preparing to stop the use of machinery in erection, compelling contractors to have all work done by hand. Mr. James E. Baggott, president of a plumbing company, showed by the printed rules of the journeymen plumbers' association that the men are now allowed to do only one-half to one-fourth the amount of work they formerly did. Yet their wages are now $4 per day, instead of $1.25 as formerly. This association is very powerful; it will not allow any man to learn the trade, no apprentices are allowed, no pipe may be even handled or carried except by members of the association, and no employer is allowed to do any work himself. If he should do any work, the labor union makes him pay to it the amount of wages which would have been paid, and imposes a fine in addition. At the Montgomery Ward Building, a dealer who purchased some old pipe was not allowed to load it on his wagon, but was compelled to employ members of the steam fitters' union to do this. Mr. George Beaumont, President of the Architects' Association, said that while lathers formerly used 60 bundles of lath in a day's work, now they are not allowed to use more than 25 bundles. The erection of one mantel is also now a day's work, while formerly three were erected. The latest move on the part of the unions is to try and induce the city council to pass an ordinance denying police protection to non-union men who work where a strike has been declared, but it seems hardly possible that this could be passed, or sustained if passed. Some months ago the unions induced the Board of Education to insert a clause in the contracts for school buildings requiring that none but union men should be employed. This, however, was carried to the courts and declared to be unconstitutional, and, therefore, invalid. Nevertheless, a strike is now declared on all schoolhouse work, because the Board will not thus limit the work, and because some of the work already done has been accomplished by non-union labor.

Under such conditions as those above noted, contractors who have given bonds for the completion of work within a certain time are put to heavy expense. Things have come to such a pass that architects and contractors can make no estimates as to cost, or as to the time of executing the work, because the unions are continually increasing their demands. The plumbers' association above referred to made a two-year agreement with the contractors, but in 2½ months they violated this and made a reduction in the amount of day's work allowed. Owners and prospective builders, therefore, are preferring to postpone building operations until the labor conditions are more stable and more favorable. The architects and contractors have, as already noted, been discussing the most practicable means of dealing with the difficulty. Three methods have been proposed: (1) The organization of an association to fight the unions by employing and protecting non-union men; (2) The opposition of the unions in municipal affairs and elections, and the instituting of suits against what Mr. Jenney terms the "labor trust;" (3) the dropping of all work until such time as the unions will come to reasonable terms and agree to abide by such agreements as they may make. As to the first plan, it is thought that it might be difficult to hold permanently the members in line, under the stress of contract requirements, intimidation, etc. The second plan is said to have been decided upon at the meeting above referred to. The third plan will, however, probably take effect to some extent independently of any formal or concerted action, since capitalists are not inclined to make investments in new buildings or in building improvements while the present labor conditions prevail. The unions, of course, claim that the men have been overworked and underpaid, and that it is necessary for them to unite for protection. They admit that their aim is to prevent non-union men from doing any work (and in some cases to prevent any new men from learning the trade), and to distribute the work among as many men as possible by allotting a maximum day's work, and by prohibiting the use of machinery, while at the same time demanding the same or even higher rates of pay.

We do not say that those who thus try to monopolize and artificially raise the price of labor are any more blameworthy than the capitalists who limit competition and raise the price of products in the market; but the labor monopolies are less likely to secure any permanent measure of success. The fact is that the high wages which skilled labor now receives were never possible until machinery had enormously increased the producing power of labor. If labor unions increase their demands beyond what is fair and reasonable, they will in the long run find themselves the worst sufferers.

We give space on another page of this issue to a contribution in which the writer proposes a new type of dam, consisting of a steel truss with all its members imbedded in concrete. So radical an innovation is not likely to be looked on with favor by the engineering profession; yet the idea is at least worth fair consideration. Such study as we have given to Mr. Fielding's proposal has led to the conclusion that his scheme to do away with the gravity cross-section, and attempt to transmit a good share of the pressure against the back of the dam to the end abutments by means of a truss would result in a design neither so economical nor so safe as the types of dams now in use.

It is to make use of his truss idea that Mr. Fielding departs from the ordinary triangular dam cross-section and adopts a rectangle. If this feature be eliminated, however, it seems to us that his idea of a dam with a steel and concrete exterior with an earth core is at least worth the consideration of engineers. To make the idea plain we have shown a rough cross-section of such a




Cross-Section of Proposed Dam with Concrete Exterior and Earth Core.

dam in the accompanying sketch. The walls for such a dam would be built up inside wooden forms in the manner familiar to all engineers, and steel enough would be imbedded in the positions shown to make the concrete safe against forces tending to bend the wall. As these forces may cause bending in either direction, two lines of steel are inserted in each case. For water tightness, reliance would be placed entirely on the wall next the reservoir. The earth heart of the dam could be of any material, the more porous the better, and drains should be laid through the lower face to prevent the accumulation of water here, and a tendency to exert hydrostatic pressure against the under face of the lower wall. If preferred, however, a layer of clay puddle could be used next the upper wall in filling the interior.

We do not say, of course, that such a structure would be better than a masonry dam, or even a well-made earth fill with masonry heart wall. We merely suggest that in certain locations and conditions—after the prices of iron get back to a normal basis, for example—it might, perhaps, be a cheaper structure.

A change in the system of giving degrees in engineering is now being considered by the Armour Institute of Technology, of Chicago, and Prof. C. V. Kerr, Chairman of the Committee on Degrees, is sending out a circular of enquiry to obtain the opinions of engineers on this subject. From this it appears that the Institute is now giving the graduates from the four years' course in engineering the degree of Bachelor of Science (B. S.) in mechanical, electrical or civil engineering, as the course may indicate. A number of engineering schools do the same, and give the full engineering degree after two or three years' practice, while other engineering schools give the degree (C. E., M. E. or E. E.) on graduation. The specific questions propounded in the circular are as follows:

(1) Should the engineering degree be considered as merely an academic degree like the B. A., or should it be considered a professional degree like M. D.?

It seems to us that it should be considered as an academic degree, since no amount of purely academic work can make a man an engineer. It is educational and preparatory work, fitting the student for the practical work of his future career. To give a graduate a degree of C. E., etc., is meaningless from a professional point of view. The M. D. degree is a little different, for while these

FIG. 2.—PILE DRIVER ARRANGED FOR TRANSPORTATION.

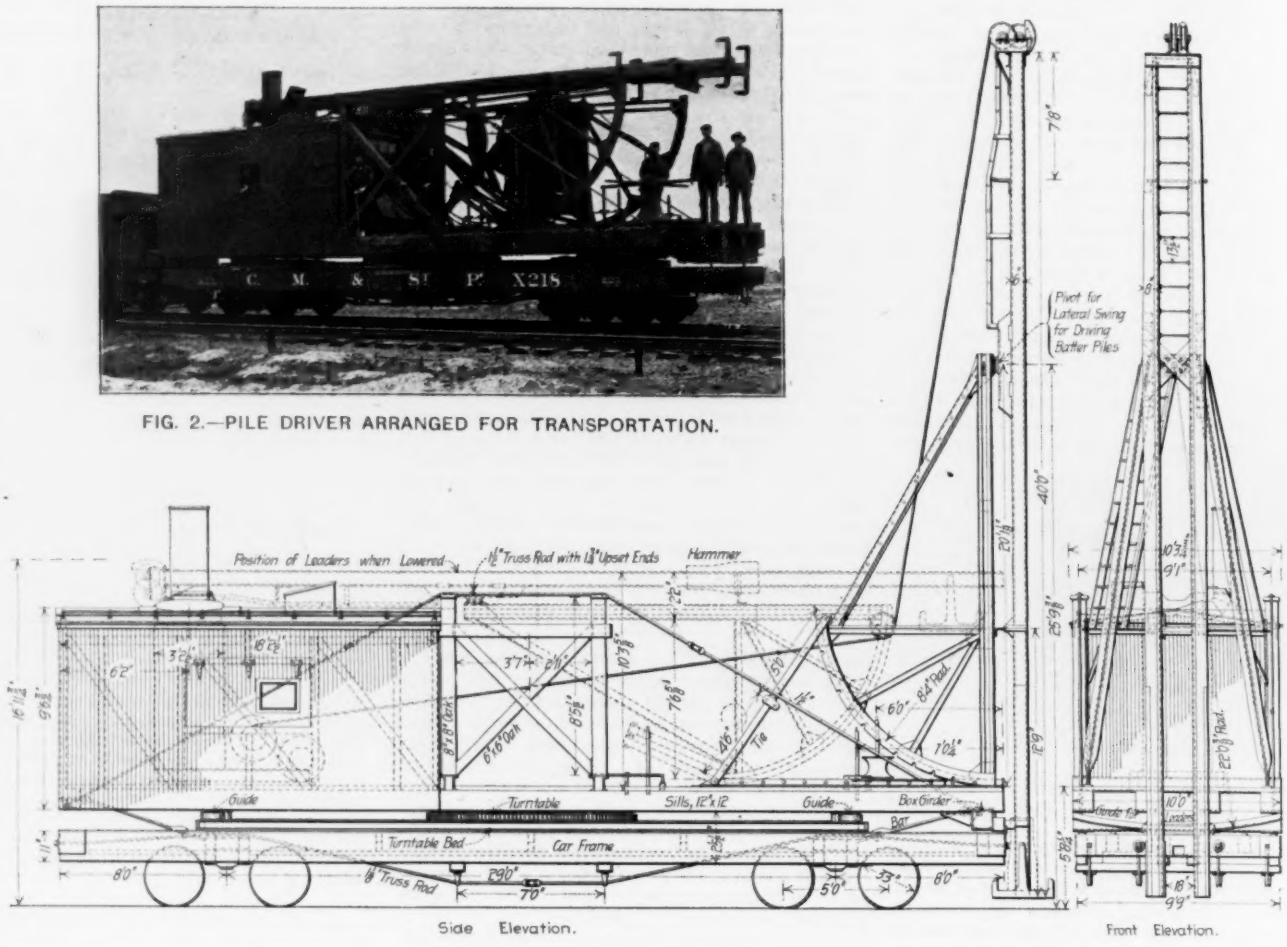



FIG. 1.—SIDE ELEVATION.

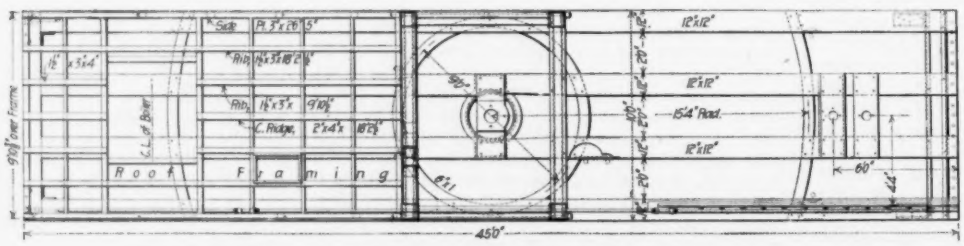



FIG. 7.—PLAN OF ENGINE BED OR UPPER DECK FRAMING.

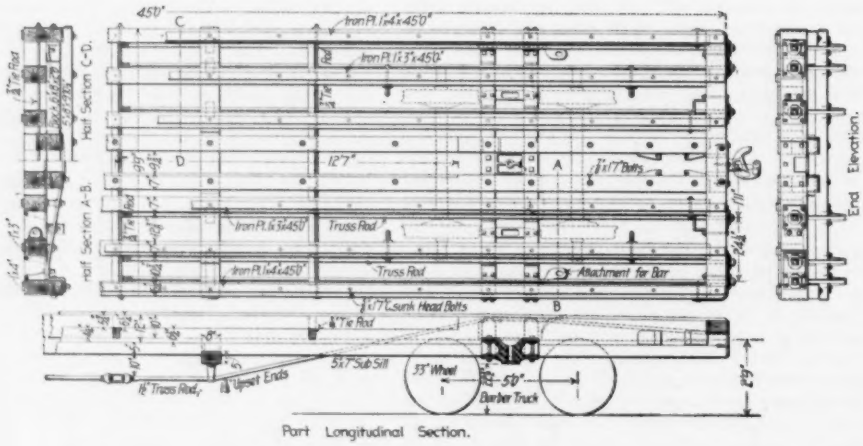



FIG. 6.—PLAN AND SECTIONS SHOWING CAR FRAMING.

RAILWAY
TRACK
PILE DRIVER.
CHICAGO,
MILWAUKEE & ST. PAUL RY.

Onward Bates, M. Am. Soc. C. E.,
Eng. and Supt. of Bridges
and Buildings.

G. W. Smith, Asst. Supt. of Bridges
and Buildings

J. N. Barr, Superintendent of Motive Power.

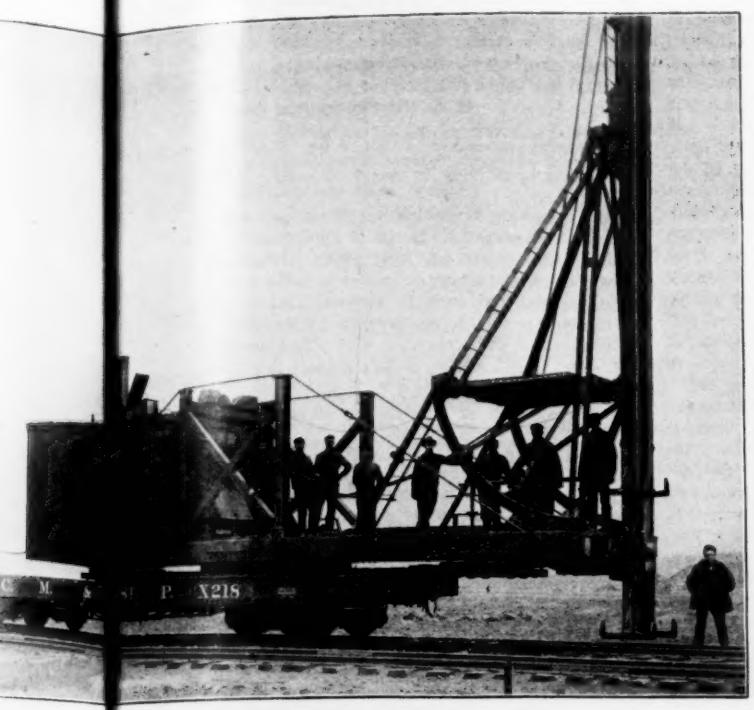


FIG. 3.—DRIVING PILES IN ADVANCE.

FIG. 4.—DRIVING PILES ALONGSIDE THE TRACK.

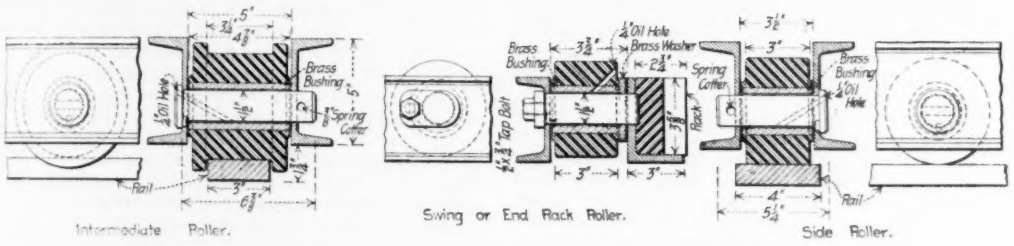



FIG. 9.—DETAILS OF TRAVELING AND SWINGING ROLLERS.

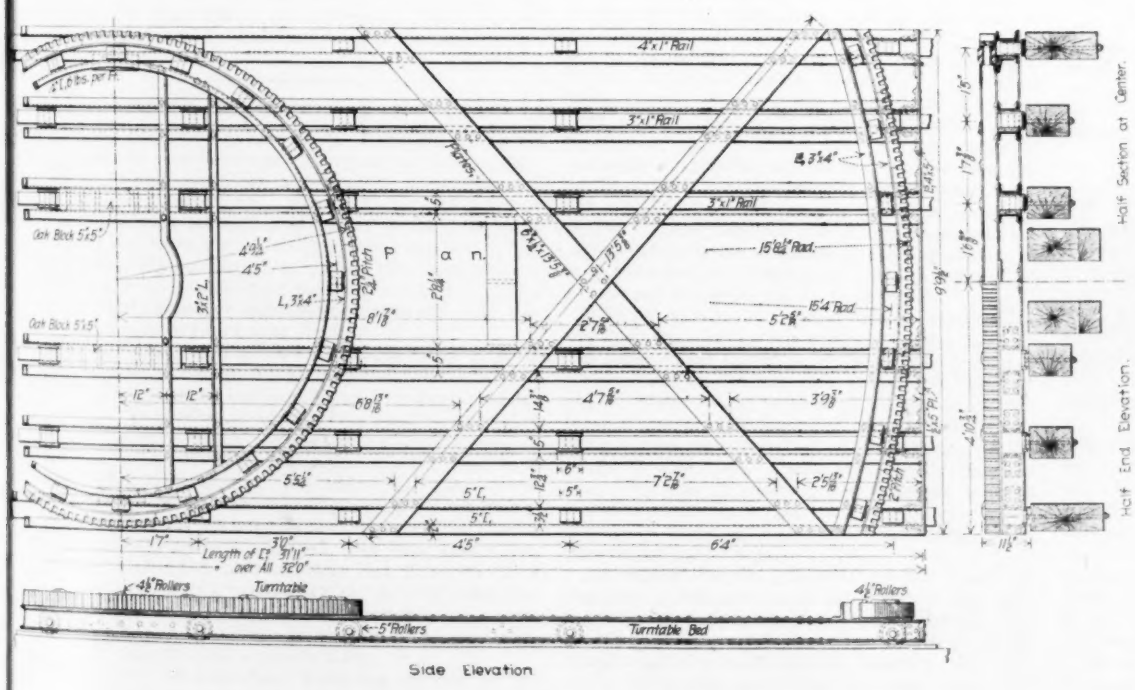



FIG. 8.—PLAN OF TURNTABLE BED AND ROLLER TRACKS.

FIG. 5.
DRIVING BATTER PILES.

initials added to the name of a newly fledged graduate cannot make him an experienced or efficient doctor, yet their use by unauthorized persons is prohibited by law. Therefore they have some actual meaning, however limited, whereas there is nothing to prevent anybody, graduate or not, from styling himself C. E.

(2) If we consider the engineering degree as professional or descriptive, like the M. D., and merely indicating the nature of the student's intended career, is it proper to grant the engineering degree, M. E., C. E. or E. E., at the end of a strong four years' course?

Under the conditions stated, it might be proper to do this, though it would undoubtedly be better even then to decide that the degree should only be given after practical experience. As we have above stated, however, it does not appear to us that engineering degrees should be considered as "professional."

(3) If it is thought best to give the B. S. degree to students on graduation, and to withhold the engineering degree until justified by judgment and experience gained in practice, should the standard be equivalent to that maintained by the American Society of Civil Engineers, the American Society of Mechanical Engineers, or the American Institute of Electrical Engineers for admission to membership?

We see no reason why the engineering schools should not, under such conditions, follow closely upon the lines laid down by the engineering societies. The requirements, however, should not be based on those of admission to full membership in the societies, but upon the second class, or associate membership.

(4) If the engineering society standards require too much, what would you propose?

We have already shown that the second class standards of the societies should be followed, since a man whose qualifications entitle him to admission to this class (as Associate Member) should be entitled to receive his engineering degree. There might be some reduction made, however, in the number of years of experience required. In the American Society of Civil Engineers, an Associate Member (if a college graduate) must be 25 years of age, have been in active practice for four years and have been in responsible charge of work for at least one year. It would probably not be unreasonable to reduce the requirements for the degree to an age of 24, with two years' practice and one year in responsible charge. In the American Society of Mechanical Engineers, an Associate Member must be at least 26 years of age, and competent to take responsible charge of work, or must have served as a teacher of engineering for more than five years. These requirements might reasonably be adopted for conferring the degree, except that the age limit might be reduced to 24. It may be well to point out, in conclusion, that nothing is gained by the profession, the college, or the graduate, by granting degrees too early or too cheaply.

## TESTING THE RESILIENCE OF STEEL.

We reprint on another page of this issue a paper recently read before the American Society of Civil Engineers, describing a new form of machine for making impact tests. The author of the paper is Mr. S. Bent Russell, well known to the profession by his work in connection with the St. Louis Water-Works extension; and he has described one of the most interesting and important departures in the testing of engineering materials that has been recorded in a long time.

More than five years ago, in our issue of Aug. 24, 1894, we pointed out that the resilience of a material is to an engineer its most important quality. He reaches an idea of this quality, according to present practice, by measuring the strength of the material under a steadily applied load in a testing machine, and considering with this its observed stretch under a load reaching to the breaking point. It is a notable fact, however, that many engineers are not satisfied with this test alone, and demand in addition some test under shock, a drop test as it is commonly called, that shall furnish a direct indication of the toughness of the material or its ability to withstand without rupture the effect of a severe blow.

Under the drop test, materials are almost invariably stressed either transversely or by direct compression. Both these methods, however, are better suited to large pieces of completed work, such as car axles, rails, wheels, etc., than to the testing of the small specimens which are necessarily used while material is in the process of manufacture. For this reason the idea has occurred to many persons that a tensile impact test which could be made with the same accuracy and uniformity as the ordinary tensile test under a static stress would be of great use to the engineering profession.

To devise such a tensile impact test, is the task which Mr. Russell has undertaken; and he deserves great credit for the ingenuity which he has displayed. The general design of the machine, as described in his paper, seems admirably adapted to its ends. The use of a pendulum as a falling weight makes possible a very exact determination of the foot-pounds of work expended in effecting the fracture; and is likely to be a feature of all future machines for testing small specimens by impact.

The great difficulty in the impact testing of specimens is the determination of the losses of energy. In an ordinary testing machine we know that, within small limits of error, every pound indicated is sustained by the specimen under stress. In an impact test machine we can ascertain the foot-pounds of energy in the blow delivered, but how much of that energy is absorbed by the specimen itself?

In Mr. Russell's machine it has been attempted to reduce the diversions of energy to the least possible amount, and we believe with fair success. Briefly stated, the specimen to be tested has heads of a T-shape. One of these is held by a fixed support, while the other is held by a so-called "fork-bar," which receives the impact of the hammer and transmits it to the specimen. Part of the energy of the hammer is used in bending the forked bar (within its limit of elasticity, of course), and part in giving to the fork-bar a velocity equal to that of the hammer itself. Mr. Russell discusses theoretically the magnitude of the energy absorbed in these two ways, and concludes that not more than 10% at most of the energy of the falling hammer will be spent in this way.

There is, however, another source of loss inherent in all impact tests, which Mr. Russell does not mention in his paper; and we think it not impossible that this loss may amount to more even than the other two combined. This is the loss of energy, or rather its transformation into heat, at the striking surfaces. A steel hammer struck on an anvil rebounds, but not to the full height from which it fell. Part of the energy of the blow goes to heat the metal of the hammer and anvil, first at the surfaces of contact and then, by conduction, through the whole mass of metal. In this way the blacksmith, striking cold iron, or the carpenter, driving a nail, may heat a hammer until it is too hot to be touched. This could not happen if the tool steel of the hammer were perfectly elastic. No perfectly elastic body exists.

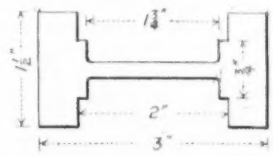
As we have said, it is likely that quite a percentage of the hammer's blow in Mr. Russell's machine is transformed to heat at the striking surfaces; but this loss, even if considerable, need not destroy the value of the tests. If they are properly made, the loss due to this cause will be proportional to the resistance of the specimen, it is reasonable to presume; and hence the test is as fair for one specimen as for another.

Turning now to the actual results obtained in the tests reported by Mr. Russell, we find that he has given them in terms of the inch-pounds per square inch of the net cross-section of the test piece. This was necessary, because of the form of test-piece chosen; but without questioning the practical usefulness and fairness of the results stated in this form, it still seems to us that the proper method to make a resilience test and to state its results, is to test the resilience of a given volume of metal, and report it as so many inch-pounds per cubic inch.

The nicked test piece adopted by Mr. Russell is designed to concentrate all the energy of the blow in the plane joining the two opposite nicks. But if this were actually done, an infinitely small shock would be sufficient to fracture the test piece. This may seem absurd at first sight, but the reason for it is simple. The work imparted to the specimen can only be absorbed by the yielding or stretching of the specimen under the applied force. According to the familiar proposition of mechanics: The sum of the external work done must equal the sum of the internal work done. The foot-pounds of the falling weight must be absorbed by the resistance of the metal which receives it, acting through the distance by which the metal is stretched. It is the whole test piece, however, that sustains stress by the blow, and not the infinitely thin plane through its least cross-section. That has no thickness and cannot stretch. If the work of breaking could be absolutely concentrated into this plane, and no stress were imparted to any other portion of the test piece, then the work required to break the test piece would be the product of the ultimate strength of the net section, and the distance required to move one portion away from the other to overcome the molecular attraction.

Referring now to Mr. Russell's table of results, we see that the quantity which he calls "inch-pounds per square inch of section at nick" really means that the given number of inch-pounds (or a somewhat less number, if we allow for the losses noted above), was spent in stretching the test piece on either side of the nicked section or plane of fracture. Part of this metal—that lying nearest to the break—was strained beyond its elastic limit, and in all probability it was this part which really absorbed most of the work. The other parts of the test piece, beyond the nicks, can hardly have been strained to the elastic limit, and hence it is reasonable to believe that they did not absorb much work.

Our chief criticism of Mr. Russell's work, then, is that he has adopted a wrong form for his test piece. The proper form, it seems to us, would be a straight piece having a cross-section not more than one-third, and preferably one-fourth as great as the section of the test piece at the heads. This reduced section might be an inch or two in length, and there should be a square shoulder where it meets the heads of the test piece, or at most a fillet of very small radius. The accompanying sketch will represent the general form which we propose.




Let us see how much energy we may reasonably expect to be required to fracture such a test piece. Taking its thickness at ¼-in., the cross-section will be 3-64 sq. ins. The static stress required to break it, assuming an ultimate strength of 60,000 lbs. per sq. in., will then be 2,813 lbs. The stretch (assuming its percentage of elongation at 33⅓%), will be 7-12 in. Then the work done will be, in inch-pounds:

$$\frac{2{,}813}{2} \times \frac{7}{12} = 820.$$

It would appear from this computation that Mr. Russell's machine should be easily capable of breaking test pieces of the form proposed, and of much larger section if desired.

We have already stated that theoretically the resilience of a perfectly homogeneous material should be a fixed quantity for a given unit volume. All materials, however, are far from homogeneous. In breaking an ordinary test piece in a static machine it is only a small part of the reduced length of the specimen that draws down at the final fracture. It will probably be found, therefore, that the resilience per unit volume determined by Mr. Russell's machine will vary greatly with the form of the test piece. A reduced section 1 in. long and of 3-16 sq. in. cross-section, for example, would probably give a quite different result from a test piece 3 ins. long and of 1-16 sq. in. section. What proportions of test piece will best bring out the characteristics of the material tested can, of course, be only determined by experiment.

A field in which the machine seems to offer much of interest is the measurement of resilience within the elastic limit. It is this resilience of which we make most frequent use. The resilience beyond

the elastic limit is a very desirable reserve; but we never wish to call upon it except in an emergency. For tests of this sort a much larger section could be adopted. For example, the work required to stretch a test piece with a reduced section of 1 sq. in. 8 ins. in length to its elastic limit of, say, 33,000 lbs., is as follows:

Assume modulus of elasticity to be 30,000,000. Then a force of 33,000 lbs. stretches a piece of steel of the given section 0.0011 of its length; or the total stretch in 8 ins. will be 0.0088-in. The mean stress is 33,000 ÷ 2 = 16,500 lbs., and multiplying this by the stretch above found, we have the total work done in stretching 8 cu. ins. of steel to its elastic limit as 145.2 inch-pounds, or 18 inch-pounds per cu. in.

The practical value of researches of this sort is apparent. For example, it is only within a short time that engineers have learned that the elastic resilience of steel of moderate hardness is greater than that of the softer and more ductile steels. Studies of this sort could be extended to many other metals of whose elastic and ultimate resistance to shock we now know very little. That an impact test is well calculated to detect inherent brittleness in materials has long been well understood, and we anticipate a large extension of its field of usefulness now that its applicability to the testing of small specimens has been established.

## LETTERS TO THE EDITOR.

### Theory of the Two-Hinged Arch.

Sir: In Part II. of the article on the "Theory and Calculation of the Two-Hinged Arch," in Engineering News of Aug. 24, there are several errors:

In Table I. $\frac{y^2 l}{r^2}$ for piece 5 is given as 160 instead of 1,620; for piece 10, 1,314 should be 1,133.3.

In Table II. $\frac{m}{y}$ for piece 6 should be zero in every column, as this piece is not stressed when the structure is considered a simple truss under vertical unit loads, hence m = 0.

In paragraph 6 for stress in 3:

s = 3.1 [— 36.7 — 22.82 A] should be s = 3.1 [— 51.8 — 23.4 A], as — 36.2 is the figure for the live load compressive stress only and should be — 51.8 for the dead and live load compressive stresses combined.

Instead of using the troublesome equations (10), (11), (12), (13) and (14) for moments, I would suggest using the stresses ($s_1$) in each piece calculated as for a simple truss under vertical unit loads for:

$$H = \frac{\Sigma m \frac{y l}{r^2 A}}{\Sigma \frac{y^2 l}{r^2 A}} \text{ is equal to } \frac{\Sigma s_1 \frac{y l}{r A}}{\Sigma \frac{y^2 l}{r^2 A}}$$

and the stresses ($s_1$) might be quickly found by diagram, the summation to be made regardless of the sign of ($s_1$).

Yours truly, Edw. J. Odlum, B. A.

St. Catharines, Ont., Oct. 15, 1899.

### Heavy Compound Consolidation Locomotive on the Southern Pacific Ry.

Sir: In your issue of Oct. 26 occurs a very interesting article on a heavy twelve-wheeler recently built for the Illinois Central. In the list of heavy locomotives with which you compare this one, you give the dimensions of a Southern Pacific twelve-wheeled compound built by the Schenectady Locomotive Works. This is by no means our heaviest mountain engine, but the compound consolidation, whose dimensions are given on the attached slip, is very much more powerful and one of the heaviest mountain engines we now operate. Thinking that the above would be of interest to you for future comparisons, I thought it well to draw your attention to the matter.

Yours truly, J. Kruttschnitt,
Fourth Vice-President and General Manager,
Southern Pacific Co.

San Francisco, Cal., Nov. 3, 1899.

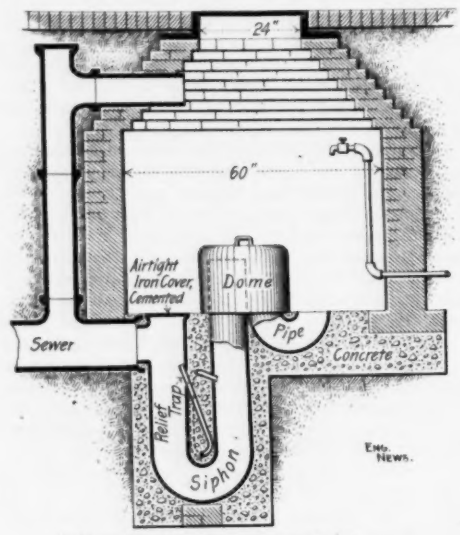
(We append the list of dimensions sent by our correspondent as follows.—Ed.)

Dimensions of Southern Pacific Consolidation Locomotive.

| | |
|---|---|
| Builder | Schenectady |
| Driving wheels | 4 ft. 9 ins. |
| Driving wheel base | 15 " 8 " |
| Total wheel base | 24 " 4 " |
| Weight on drivers | 173,000 lbs. |
| " total | 193,000 " |
| " engine and tender | 283,700 " |
| Compound or simple | 2-cylinder compound |
| Cylinders | 23 and 35 by 34 ins. |
| Diameter of boiler | 6 ft. |
| Boiler pressure | 220 lbs. |
| Firebox | 10 ft. 6⅛ ins. by 3 ft. 4⅝ ins. |
| Number of tubes | 332 |
| Diameter of tubes | 2¼ ins. |
| Length of tubes | 14 ft. 6 " |
| Heating surface, tubes | 2,817.3 sq. ft. |
| " " total | 3,027.8 " " |
| Grate area | 35.3 " " |

### THE BERRY AUTOMATIC SIPHON FOR FLUSH TANKS.

In the sewer flushing tank illustrated in the accompanying cut, the siphon is of cast iron, with a web between the limbs which serves to protect the relief trap. This siphon is set in concrete, the




Automatic Siphon for Flush Tank.
Berry Flush Tank Co., Iowa City, Ia., Makers.

top of the short limb being level with the floor of the tank and covered with an iron lid sealed with cement, so as to be water-tight and air-tight. In the concrete floor of the tank is set a semicircular pipe, with one end close against the long limb of the siphon. An iron dome rests on the floor of the tank, and covers one end of this pipe and the long leg of the siphon. By removing the iron cover, the sewer and the short limb of the siphon can readily be inspected, this being one of the special features of the device. Water is admitted at any desired rate through the small iron pipe at the side of the tank. When the head of water in the tank is sufficient to overcome the weight of the column of water in the small trap, the air and water in this trap are suddenly blown out, the air confined in the siphon escapes through the relief trap, and the water in the tank then flows over the top of the long leg of the siphon and is discharged into the sewer. The rush of water carries dirt and other matter into the semicircular pipe and out through the siphon, the tank being practically self-cleaning, and having no water on the floor after the discharge.

The relief trap is so shaped that floating matter cannot enter to obstruct it, and it is filled entirely by the overflow from the large siphon. It is out of action during the action of the large siphon. These siphons have been used at Iowa City, Ia., and are well spoken of by the City Engineer, Mr. C. S. Magowan, and his assistant, Mr. W. H. Cochran. They are manufactured by the Berry Flush Tank Co., of Iowa City, Ia., and we are indebted to that company for blue prints and other information.

### AMERICAN TANK LOCOMOTIVES FOR FOREIGN RAILWAYS.

Among the orders for locomotives placed with American locomotive works by English railways some months ago were orders for ten tank engines, and as side tanks are very rarely employed in American practice, these engines are of somewhat peculiar interest. The engines are of two types, one having six driving wheels and a trailing pony truck, and the other having eight driving wheels, also with an English form of trailing truck or radial axle. The five six-coupled engines are for the Barry Ry., and the eight-coupled engines for the Port Talbot Railway & Docks Co., both railways being situated in the South Wales coal district. All these engines have been built by the Cooke Locomotive Works, of Paterson, N. J., to whom we are indebted for information regarding them.

The six-coupled engines are distinctly English in general appearance, and are representative of a very large class of side-tank engines used in local and short distance service on English railways. They were built to specifications furnished by the railway, modified in some respects at the builder's request. The railway also furnished a few detail drawings, and some of the special fittings were sent over from England. Bar frames are used forward of the plate frames which carry the cab and the rear tank. The cylinders, saddles, motion and valve gear are of American design. No spring equalizers are used, and the English fittings include the following: Throttle valve and lever, hook couplings and draw springs, spring buffers, rail knives, Ramsbottom duplex safety valves, injectors, lubricators, and vacuum brake fittings. The injectors are of the exhaust steam type, placed on the running board in front of the tank, with a large pipe connection, as shown. There are three tanks, one on each side of the boiler and one under the rear coal space, the latter being connected with the side tanks by the large pipe shown behind the steps. The engines are intended for mixed traffic on a railway of standard gage, using a good quality of soft bituminous coal as fuel. The general dimensions of the engines are given below, in our standard form:

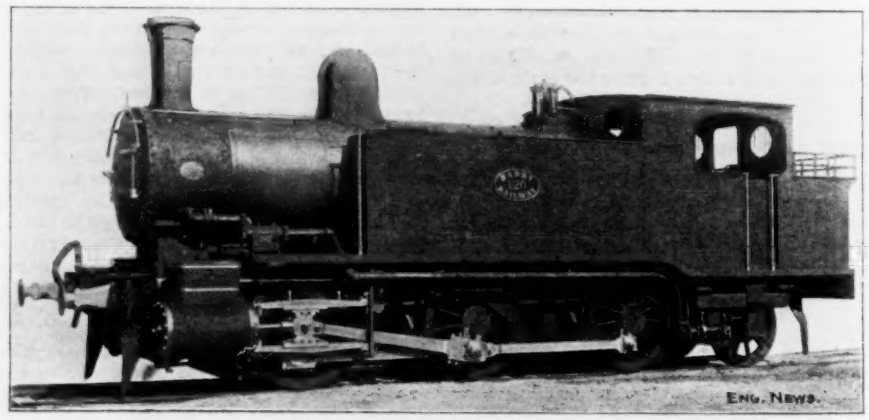



FIG. 1.—SIX-COUPLED TANK ENGINE FOR THE BARRY RY. (ENGLAND).
Cooke Locomotive Works, Builders.

Dimensions of American Tank Locomotives; Barry Ry. (England.)

| | |
|---|---|
| Running Gear: | |
| Driving wheels (6) diameter | 4 ft. 3 ins. |
| Trailing wheels (2), diameter | 3 " 6 " |
| Driving and truck wheel centers | Cast steel. |
| How are driving-wheel tires secured? | Shrinkage; bolts. |
| Trailing truck, Radial; Journals, driving axles, | 8x8⅞ ins. |
| Wheelbase: Driving | 14 ft. 5 " |
| Total engine | 20 " 8 " |
| Driving wheels having blind tires | Middle (main) pair. |

| | |
|---|---|
| Weight in Working Order: | |
| On driving wheels | 100,000 lbs; truck wheels.. 26,000 lbs. |
| Engine total | 126,000 " |
| Does counterbalance conform to M. M. Assoc rules? | Yes. |
| Cylinders | 18 × 24 ins. |
| Form of crosshead and guides | Alligator. |
| Side rod | Strap ends. |
| Valve Gear: Type | Stephenson link. |
| Ports, steam | 1¼×17 ins.; Ports, exhaust 3×17 ins. |
| Bridges, width | 1⅝ " ; Eccentrics, throw 5 " |
| Slide valves, style | Richardson balanced, with Allen ports. |
| " maximum travel | 5½ ins. |
| " inside lap. None; outside lap | ⅛-in. |
| Boiler: Type | Straight top. |
| Diameter barrel, inside smallest ring | 4 ft. 5⅛ ins. |
| Diameter of dome | 2 ft. |
| Thickness, barrel plates, | 9/16-in. |
| Thickness smokebox tube-plate | ½-in. |
| Horizontal and circumferential seams | Double riveted. |
| Joints | Butt; Rivets, diameter ⅞-in. |
| Height from rail to center line | 7 ft. 5½ ins. |
| Length of smokebox | 2 "10¼ " |
| Form of spark arresting device | None. |
| Injectors | Davies & Metcalf (English); exhaust steam. |
| Working steam pressure | 160 lbs. |
| Firebox: Type | Deep, between frames. |
| Length, inside. 6 ft. 0⅝ ins.; width, inside | 3 ft. 4⅛ ins. |
| Depth at front. 5 " 9 " ; depth at back | 4 " 4¼ " |
| Thickness, side plates. ½-in.; back plates | ½-in. |
| Thickness crown plates ½-in.; tube plates | 1-in. |
| Crown stays. Crown bars; Grate bars | Rocking. |
| Is fire-brick arch used? | No. |
| Stay bolts. Solid; diameter. ⅞-in.; pitch | 4 ins. |
| Water spaces, width at front, back and sides | 3 " |
| Tubes. Brass; No. | 181 |
| Thickness, ends. Front, No. 11 W.G.; Back, No. | 12 W.G. |
| Pitch | About 2¾ ins. |
| Diameter, outside | 2 ins. |
| Length over tube plates | 11 ft. 2½" |
| Total area of tube openings | 204.9 sq. ft. |
| Heating Surface and Grate Area: | |
| Heating surface, tubes (interior area) | 1,049 " |
| " " firebox | 98 " |
| " " total | 1,147 " |
| Grate area | 21 " |
| Miscellaneous: | |
| Exhaust nozzle (single) diameter | 5¼ ins. |
| Exhaust nozzle, distance below center line of boiler | ¼-in. |
| Smokestack, diameter at top | 19¼ ins. |
| " at base | 16⅜ " |
| " height above smokebox | 3 ft. 2¼ " |
| " height of top above rail | 13 ft. |
| Capacity of tank | 1,600 gallons. |
| Capacity of coal space | 3,500 lbs. |
| Brake fittings | English vacuum. |

The eight-coupled engines are of very similar design, but somewhat longer, with the three rear pairs of coupled wheels bunched together under the tanks. The two middle pairs of driving wheels have blind tires. The boiler is of the extended wagon-top type, with dome and safety valves on the wagon-top, while the sandboxes are under the running boards.

The firebox is of copper and fitted with rocking grates, while the tubes are of brass.

Two heavy side-tank engines of rather peculiar design have recently been built for the Dominion Coal Co.'s line on Cape Breton Island (Nova Scotia), by the Schenectady Locomotive Works, of Schenectady, N. Y., and one of these engines is shown in Fig. 2. The railway is short, and tank locomotives are used to obviate the necessity of turning the engines at the ends of the road. The engine illustrated has eight driving wheels, while the other has only six driving wheels, but in other respects the engines are practically identical. The side tanks are placed on the running board, and there is a tank behind the cab, carried by the trailing two-wheel truck. The side and end tanks are connected by pipes under the cab. The coal space is carried high up at the back of the cab, as in some of the Chicago suburban engines of the Forney type. A leading pony truck is used, and it will be noted that the pilot is faced with sheet steel. The guides are of the Laird type, and all the rods are of I-section, while the side rods have solid ends. The engines are for standard gage tracks, and will use bituminous coal for fuel. The six-coupled engines are of very similar design, having driving wheels 4 ft. 7 ins. diameter; cylinders, 19 × 26 ins.; and weighing 172,000 lbs., with 122,000 lbs. on a driving wheelbase of 13 ft. 2 ins.

The leading dimensions of the English and Canadian eight-coupled tank engines are as follows:

| | Barry Ry. | Dom. Coal Co. |
|---|---|---|
| Driving wheels | (8) 4 ft. 4 ins. | (8) 4 ft. 7 ins. |
| Truck wh'ls, leading. | None. | (2) 2 " 6 " |
| Truck wh'ls, trailing. | (2) 3 ft. 6 ins. | (4) 2 " 4 " |
| Journals, driv'g axles | 8 × 8 5/16 ins. | 9 × 10 ins. |
| Wheelbase, driving | 15 ft. 6 ins. | 15 ft. 0 ins. |
| Wheelbase, total | 22 " 1 " | 36 " 3 " |
| Weight on drivg whls | 137,000 lbs. | 170,000 lbs. |
| On leading truck | ..... | 18,000 " |
| Total | 169,000 lbs. | 239,000 " |
| Cylinders | 19 × 24 ins. | 22 × 28 ins. |
| Slide valves, travel | 5½ ins. | 5½ ins. |
| Steam ports | 1½ × 17 ins. | 1¼ × 18 ins. |
| Exhaust ports | 3 × 17 ins. | 2¾ × 18 " |
| Lap, inside & outside | None, and 7/16-in. | 1/32-in. and ¾-in. |
| Boiler, diam. barrel. | 4 ft. 8 ins. | 6 ft. |
| H'ght, rail to c. line | 7 "11½" | ..... |
| Working pressure | 175 lbs. | 200 lbs. |
| Firebox, length | 7 ft. 0 ins. | 9 ft. 6 ins. |
| Width | 3 " 6 " | 3 " 6 " |
| Tubes, No. and diam. | 219 and 2 ins. | 348 and 2 ins. |
| Length | 11 ft. 11 ins. | 13 ft. 10 ins. |
| Heating surf., tubes | 1,361 sq. ft. | 2,513 sq. ft. |
| Of firebox | 128 " | 177 " |
| Total | 1,489 " | 2,690 " |
| Grate area | 24.5 " | 33.21" |
| Smokestk, rail to top | 13 ft. 2 ins. | 14 ft. 0 9/16-in. |
| Capacity of tank | 2,000 gallons. | 4,200 gallons. |
| Of coal bunker | 2 tons. | 4 tons. |

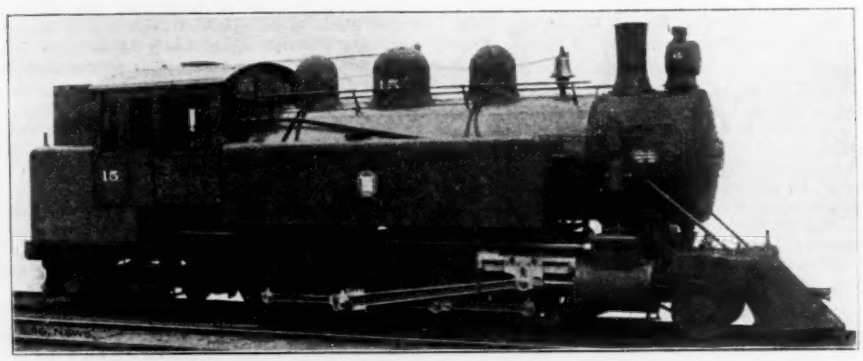


FIG. 2.—EIGHT-COUPLED TANK ENGINE FOR THE DOMINION COAL CO. (NOVA SCOTIA).
Schenectady Locomotive Works, Builders.

## EXAMINATION QUESTIONS FOR THE POSITION OF CITY ENGINEER.

An examination of candidates for the position of City Engineer of the city of Alexandria, Va., was held at that place on Nov. 10. The Board of Examiners was made up of Messrs. Wm. Atlee, Engineer of the Washington & Gettysburg R. R.; W. H. F. Finke, Engineer of Bridges of the Southern Ry., and Chas. B. Ball, M. Am. Soc. C. E., of Washington, D. C. The questions used in the examination were as follows:

I.

EDUCATION AND EXPERIENCE.

1. What is your age? State your present employment and address.

2. What is the extent of your general education? State whether you have received a common school, high school or college education.

3. Have you pursued a course of study in any institution or with a civil engineer which would fit you for the position of city engineer? If you have received any degree, state by what institution conferred and in what year.

4. State your practical experience as a civil engineer, giving details as to the nature of the duties performed and the length of time employed.

5. Have you a practical knowledge of any mechanical trade? If so, state any essential facts respecting the conditions under which you acquired such knowledge or have practiced it.

II.

PRACTICAL AND THEORETICAL QUESTIONS IN ENGINEERING.

1. (a) What are the main elements governing the design of a sewerage system, other than the method of disposal and considerations of flushing and ventilation?

(b) Describe in detail an ordinary method of giving lines and grades for large water mains or sewers.

(c) Name three common methods of driving piles, and state under what circumstances each may be adopted.

2. Describe in detail the duties of an inspector on a public work.

3. (a) A circular steel bar, 4 ins. in diameter and 20 ft. long equals in weight a hexagonal bar 30 ft. long. Find size of hexagon to nearest hundredth of an inch.

(b) Show a form of field notes used for running curves and a form for level book.

4. (a) What are proper proportions of sand, broken stone and cement in a concrete for (1) a building foundation, (2) an abutment under water, (3) a sewer arch?

(b) Write a specification for a concrete suitable for one of these conditions.

5. (a) What is the office and influence of a waste weir? Discuss the conditions which govern the length of overfall.

(b) Indicate by a sketch some common form of weir cross-section.

6. (a) Enumerate the precautions that must be taken in order to obtain the best results in leveling with a Y-level and ordinary rod.

(b) Describe the manner of making a survey extending the city limits to include an addition of 40 acres.

7. (a) Make sketch cross-section of half of a pavement suitable for heavy traffic, showing sidewalk and curb.

(b) Discuss the relative merits of asphalt, brick, granite block and asphalt block for roadway pavements.

8. (a) Describe the type of foundation known as "Chicago foundation" and explain the principle on which its application depends.

(b) Describe what is meant by mill construction in buildings.

(c) State briefly the characteristics of good brick and of framing timber.

9. Make a cross-section of a bridge having a 50-ft. clear span for a street with 40-ft. roadway, two sidewalks 10 ft. each, showing floor construction for a vitrified brick roadway and granolithic sidewalks.

10. Make a sketch showing a section of a stone abutment 30 ft. in height under ordinary condition of foundation.

## IMPACT TENSILE TESTS OF STEEL.

In our issue of Jan. 13, 1898, we described a new form of impact testing machine designed for making transverse tests, by Mr. S. Bent Russell, M. Am. Soc. C. E. The tests conducted with this machine gave such a great range of values of resilience of the steels tested that Mr. Russell was led to think that transverse breaking gave an unfair advantage to the softer steels, and he therefore determined upon making impact tensile tests of similar steels. This new series of tests was carried out on the original machine, with such additional attachments as were necessary to provide for handling test pieces in tension. As a result of these tensile tests on the original machine, it was decided to build an entirely new machine for making both tensile and transverse impact tests. The construction of this new machine is shown by Figs. 1 and 2. In principle it will be seen the new machine is exactly like the original machine for making transverse impact tests, the blow being delivered by a heavy pendulum bar of steel hung on a horizontal shaft with roller bearings.

Referring first to the new machine shown in Figs. 1 and 2, it may be stated that the hammer or pendulum weighs 200 lbs., as compared with 103 lbs., which was the weight of the hammer in the original machine. The striking edge of this hammer is tool steel. The tensile test attachments consist of a bracket (shown in section C-D, Fig. 1), and a fork (shown in the small plan, Fig. 1, and enlarged in Fig. 8). The bracket used is of cast iron. It is very heavy and rigid, and is provided with a slotted plate of tempered steel. This plate receives the T-head of the specimen, and all bearing surfaces are ground true. There is a small shelf on the face side of the bracket which supports the fork end of the fork-bar when in position for a test. The other end of the fork-bar is held up by an adjustable support. When in position the axis of the fork-bar is on a level with the center of percussion of the pendulum.

In operation the hammer is raised a certain recorded distance, and let fall, so as to strike the test piece and break it. After breaking the test piece the bar swings up beyond the vertical position, and this distance of rise is recorded as well as the distance of fall. From the two records the force of the blow given the test piece is calculated. The paper continues as follows:

> The center of gravity of the pendulum or hammer is found by trial before mounting, and, at the same time, the hammer should be weighed, as the force of the blow is to be measured by the fall of the center of gravity in inches and the weight of the hammer in pounds. The pendulum is, of course, provided with an attachment for reading the height through which the acenter of gravity falls. The height through which the center of gravity rises after passing its lowest point is also shown.
>
> We are now provided with a machine for breaking specimens in tension with a single blow. Before making actual tests, however, it is in order to consider what results will be obtained. In this paper the resilience of a specimen will be understood to mean its shock resistance or stopping power; that is, the amount of energy or work that will be required to rupture it. This energy will be expressed in inch-pounds. If we raise the hammer 2 ins. and let it fall so as to break a specimen, and the hammer rises to a height of 1 in. after breaking the specimen, we would say that, as the hammer weighs 103 lbs., 103 in.-lbs. of energy have been absorbed, so that the apparent resilience of the specimen is 103 in.-lbs. The loss due to friction in swinging is easily allowed for, therefore it may be considered that there is no friction. In addition to breaking the specimen, there has been energy absorbed in other ways. The most important of these are the inertia and the springing of the fork-bar.

As the result of a series of experimental tests and careful calculations, which the paper gives in some detail, Mr. Russell concludes that without

further investigation it seems fair to presume that the inherent errors of this method of testing due to the inertia and springing of the fork-bar and to other causes need not exceed 10%, or, in other words, that over 90% of the blow should be absorbed by the specimen. The paper continues as follows:

In the results of the experiments no correction has been made for either the inertia or spring of the fork-bar. It is thought that, were all the corrections made, the comparative values would not be changed materially.

Preparing Specimens.—Taking up first the design of the specimen bars, we find that on account of the great toughness or resilience of steel, it is necessary to test but a small volume of the metal. As it is difficult to confine the effect of a blow to a definite volume of metal, a nicked

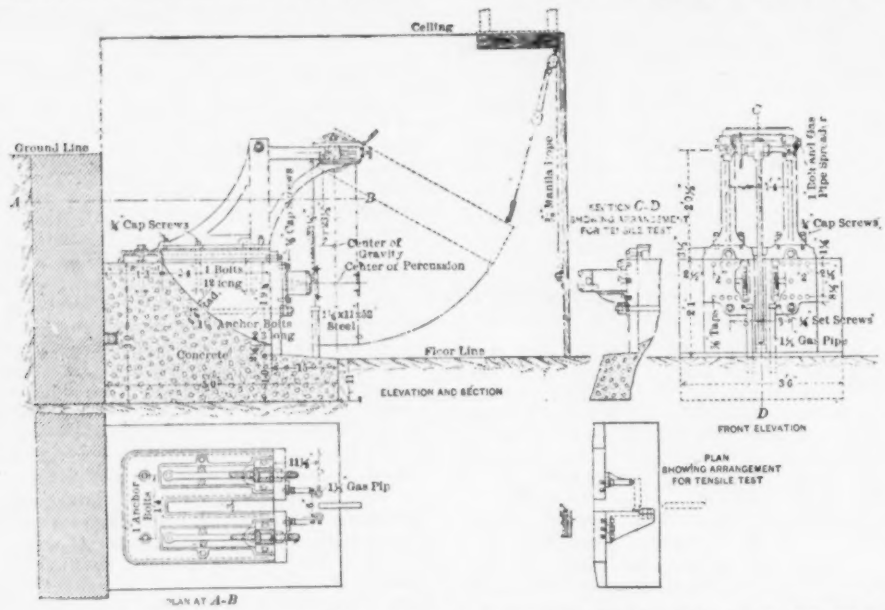



FIG. 1.—DETAILS OF IMPACT TESTING MACHINE FOR MAKING TRANSVERSE AND TENSILE IMPACT TESTS.

S. Bent Russell, M. Am. Soc. C. E., St. Louis, Mo., Designer.

section was adopted, a standard nick of simple form being used. In Fig. 2 is shown the dimensions of the specimen bars used. As they are all cut from flat sections, all the dimensions are constant, except the thickness t. To allow for the varying thickness, the resilience of a specimen is divided by the area of the cross-section at the nick, and the result is called the resilience per square inch. The results are believed to be comparable.

It should be remembered, of course, that a test specimen of different form would not give the same resilience per square inch. Objection may be made to the use of any particular form of nick, but it is believed that tests made with the form adopted give a good idea of the quality of the metal. The blacksmith judges a bar of steel by nicking it and breaking it with his hammer and anvil. We are simply improving on his method by using a nick made to gage, and measuring the energy of the blow.

The specimen bars used in the experiments were cut to shape in a milling machine, as experience showed this to be the best way to secure sharp and uniform nicks. The milling cutters were ground in a universal cutter and tool grinder, so as to secure a perfect cutting tool. A number of specimens are usually cut together on the milling machine.

Breaking Specimens.—The specimens are numbered and then calipered with a micrometer. A specimen bar is then placed in the bracket slot and the fork-bar adjusted. The hammer is raised to a given height and released. It falls, strikes the fork-bar and breaks the specimen. The height to which the hammer swings is recorded. The proper correction for friction of the hammer is noted, and the observer is ready for another specimen.

The table gives the values of resilience found with a number of samples of wrought iron and soft steel. In the last two columns are given for comparison the strength and ductility of each melt as shown by the ordinary tensile tests with the load applied gradually. The thickness t is in all cases the thickness of the plate or bar as rolled.

Table Showing Resilience per Square Inch of Nicked Iron and Steel Bars Tested by Impact.

| Metal. | Lot No. | No. of melt. | No. of tests made. | Thickness of plate in ins. = t. | Resilience, in.-lbs. per sq.in. of section at nick, = $R_s$. | Ultimate tensile strength in lbs. per sq. in.* | Percentage, elongation in 8 ins.* |
|---|---|---|---|---|---|---|---|
| Iron, Norway.. | 2 | ... | 8 | 0.25 | 7,535 | 41,500 | 28.2 |
| Tenn. comm'n | 3 | A | 6 | 0.25 | 2,506 | 55,000 | 21.2 |
| Charcoal .. | 4 | A | 6 | 0.25 | 3,648 | 52,500 | 27.5 |
| " .. | 4 | B | 6 | 0.25 | 2,885 | ..... | .... |
| Common .. | 3 | B | 6 | 0.25 | 2,115 | ..... | .... |
| Iron, common. | 5 | A | 6 | 0.25 | 2,176 | 50,700 | 14.2 |
| Common .... | 6 | B | 6 | 0.31 | 3,290 | 50,000 | 23.1 |
| " .... | 6 | C | 6 | 0.37 | 2,140 | 52,500 | 18.1 |
| " .... | 6 | D | 6 | 0.44 | 1,640 | 57,200 | 15.6 |
| " .... | 6 | E | 6 | 0.50 | 3,500 | 54,800 | 19.6 |
| " .... | 6 | F | 6 | 0.56 | 2,050 | 54,800 | 18.4 |
| " .... | 6 | G | 6 | 0.62 | 2,030 | 52,800 | 19.0 |
| Soft stl (plates) | 6 | 743 | 2 | 0.32 | 7,657 | 53,750 | 30.3 |
| " " | 6 | 743 | 2 | 0.44 | 7,000 | 54,800 | 29.6 |
| " " | 6 | 740 | 2 | 0.44 | 9,028 | 57,000 | 31.5 |
| " " | 6 | 757 | 2 | 0.32 | 7,645 | 56,900 | 30.5 |
| " " | 6 | 757 | 2 | 0.44 | 6,100 | 55,600 | 27.7 |
| " (angles) | 11 | A | 6 | 0.32 | 7,290 | 62,200 | 31.0 |
| " " | 11 | B | 6 | 0.37 | 1,550 | 54,500 | 31.5 |
| " " | 11 | C | 6 | 0.50 | 2,950 | 64,800 | 29.1 |

*The values in these columns are the result of one test only.

The steel of Lot No. 6 was basic open-hearth steel. The specimens were cut from large plates. The tests showed very uniform material. The steel of Lot No. 11 was said to be medium steel, but the tensile test indicated that it should be graded as soft steel. These specimens were cut from angles about 3 × 3 ins. in size. These tests showed a lack of uniformity in the material. All the wrought-iron specimens were cut from bar iron.

On examining the values given in the table we note that the highest value obtained with wrought iron is 7,535 in.-

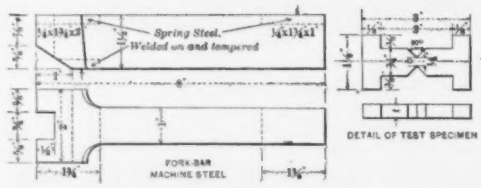



Fig 2.—Enlarged Details of Fork Bar and Form of Specimen Employed in Impact Tensile Tests of Steel.

lbs. per sq. in., with ¼-in. Norway iron. The lowest value obtained with wrought iron of the same thickness is 2,115 in.-lbs. Taking all thicknesses of wrought iron we get a range of from 1,640 to 7,535. The highest test of steel is over 9,000 in.-lbs. and the lowest is 1,550 in.-lbs. In Melt No. 743 we get practically the same results with metal of different thicknesses, while in melt No. 757 the thicker metal makes a poorer showing. This may be due to the thicker plate having been finished in the rolls at too great a heat.

A study of all the values given in the table indicates that the resilience per square inch is not proportional to the ultimate strength, nor to the proportionate elongation, nor to the product of the two. We note, too, that the proportionate range in value is greater for the resilience than for either ultimate strength or elongation.

Conclusion.—In conclusion we may review the work briefly. The tests given were made by a new method of breaking small specimens in tension by impact. We find that there are two important errors which may be said to be peculiar to the method of testing. We find the first of these or the error due to inertia, theoretically determinate. We find that the second of these errors or that due to the spring of the fork-bar is determinate to the degree that the tensile strength of the specimen is known. The other errors in the method are those common to all impact tests. We find that the results obtained are determined by the form of the specimen, and are hence only comparative. We find that the tests that have been made by this method indicate that the resilience or shock resistance of rolled steel cannot be predicted from the tensile strength and elongation. The values obtained will, of course, have but little other meaning until they have been interpreted by experience and by further experiment. It is suggested, however, that in time, tests of this sort may become a valuable aid in judging and recording the quality of structural steel.

THE BUTE DRY-DOCK, at Cardiff, England, is being widened to meet the increasing size of steamers, which now prevents the docking of two ships at once. The description furnished by U. S. Consul D. T. Phillips does not give much information concerning the engineering features, but the following plan is apparently being carried out: An excavation, 400 ft. long by 75 ft. wide, is being made on one side of the old dock, but only half the depth of the old dock. This would leave 13½ ft. of water on the blocks of the half-dock, or enough for the ordinary cargo vessel. The ship to be repaired enters the dock in the usual way, from a tidal basin, and is then hauled broadside on into the half-dock and blocked up. This arrangement leaves the original dock to be used in the ordinary way for vessels needing painting and ordinary repair. Mr. Phillips does not explain how the level of water is controlled in opening the dock for the admission of the other ships; but the change is said to add practically 50% to the earning power of the dock, at an estimated cost of $121,000.

A NEW HAVANA FLOATING DRY-DOCK is to be built to replace the one sold to Vera Cruz. According to press accounts the dock is to have a steel frame, covered with wood and sheathed with copper. It will be 360 ft. long, and 90 ft. wide, and will dock a vessel of 5,600 tons. The estimated total cost is $750,000, and the Riter-Conley Manufacturing Co., of Pittsburg, is said to have a provisional contract for the steel construction. The agent of the Havana Dry-Dock Co. in New York, is the Krawjewski-Pesant Co.

TUTUILA, the island of the Samoan group falling to the United States in the proposed arrangement between Germany and England, contains only 54 sq. miles and 4,000 population. It has the best harbor in the South Pacific, that of Pango Pango: it is deep and completely landlocked. The United States already has a coaling station there; and as a halfway point between Honolulu and Auckland and the Philippine group it has great commercial and strategic value.

UNITS OF MEASURE AND CAPACITY in nearly all cases have a primitive origin, and an excellent illustration of this is a recently published table of Siamese weights and measures, issued by the Philadelphia Commercial Museum. We print a portion of it as follows:

**Liquid Measure.**

4 chauk make 1 k'anahn, or cocoanut shell (capable of holding 830 tamarind seeds);
20 k'anahn make 1 tang, or wooden bucket.

**Dry Measure.**

830 tamarind seeds make 1 k'anahn;
25 k'anahn make 1 sat, or bamboo basket;
80 sat make 1 kwien, or cart.

TECHNICAL EDUCATION IN JAPAN is being made an important part of the general advance of that country, says the Minister of Education of Japan. The Imperial University of Tokio is well equipped with all the teachers and plant necessary for higher education of this class; and another institution has recently been founded in Kyoto, with the same objects in view. The Imperial College of Engineering, formerly connected with the Public Works Department, has been incorporated with the College of Engineering of the University. This college now has 50 professors and assistants and 384 students; of these students, 102 are studying civil engineering, 72 mechanical engineering, 36 naval architecture, 63 electrical engineering, 9 architecture, 29 applied chemistry, 59 mining enginering, 7 the technology of arms, and one that of explosives. This year 78 students graduated. Besides the University, there are 5 government, 58 public and 17 private technical schools engaged in teaching the more practical operations of agriculture, industry and commerce. In the government Higher Commercial School, with a three-year course, there are 42 instructors and 452 pupils. The Osaka Technical School, with 19 instructors and 173 pupils, prepares pupils as first-class workmen and foremen. Of the 276 foreign instructors in these schools, 124 are Americans, 69 British, 52 French and 18 Germans. The Tokio Fine Arts School has 49 instructors and 286 pupils, and the course includes drawing, painting, sculpture, architecture and industrial fine arts.

THE CHINESE WALL, about 1,200 miles long and built 200 B. C., says "Engineering," is in danger of demolition, and one American, two British and three German firms are "reported" to be bidding for the work in return for rich concessions of various kinds. Our contemporary does not explain what return China expects from the destruction of these now useless walls; nor why the Chinese conservatism that has preserved them for these 2,000 years should so suddenly disappear. Judging from their location, they are not specially valuable as building material; and they would be more useful in their present almost perfect condition as a historical relic of substantial work performed than they could be in the form of a rubbish heap.

THE GRAIN-ELEVATORS OF THE NORTHWEST have been visited by a special correspondent of the "Commercial Bulletin,' and his report may be condensed as follows: Previous accounts described the three leading Minneapolis elevator systems, the Peavey, Washburn-Crosby and Pillsbury-Washburn, aggregating nearly 50,000,000 bushels capacity. The next largest system is the Van Dusen, with 316 elevator houses and a capacity of 11,350,000 bushels. These, under various names, are scattered over Minnesota, South Dakota, North Dakota and Iowa, on the lines of railways; and its terminal elevators are all in Minneapolis. The system was started by Mr. Van Dusen 40 years ago. The third system is the Cargill, with 240 country elevators and a capacity of 4,500,000 bushels, and two terminals with a capacity of 3,500,000 bushels, or 8,000,000 bushels in all. Then the Osborne-McMillan Elevator Co. has 100 houses, mostly on the Soo Line, with a 750,000-bushel terminal at Minneapolis. This list does not include a dozen smaller country elevator companies, with terminals in Minneapolis and Duluth. As illustrating the activity in shipments of wheat, the Van Dusen Co. says that the Pennsylvania and the Baltimore & Ohio railways have averaged daily for a month past 5,000 to 6,000 cars behind their orders for grain cars between Chicago and the seaboard. In the last crop year Minneapolis alone received 90,000,000 bushels of wheat, and ground over 60,000,000 bushels of this in her own mills, and produced 15,316,415 barrels of flour.

## 2,500-HP. TRANSFORMERS; THE LARGEST IN THE WORLD.

That high potential transmission may be the most economical for even so short a distance as 2½ miles, is forcibly shown by the fact of the installation of the bank of transformers described below. The Union Carbide Co., of Niagara Falls, N. Y., recently contracted with the Cataract Power & Construction Co. for 15,000 HP., to be delivered at the carbide works at a pressure of 2,200 volts. It was evident that, if the current were transmitted at this pressure, the cost for conductors would be considerable, even though the distance was small, as given above. It was, therefore, decided to work the transmission line at 11,000 volts.

To step the current down at the receiving end, seven tranformers of 2,500-HP. capacity each are to be employed. These transformers are being built by the General Electric Co., and are double the size of the largest hitherto constructed. The total weight of each unit is 50,000 lbs., of which one-half is made up by the sheet iron used in the core. The clamps for holding the latter together weigh 4,000 lbs. The enclosing case is about 11 ft. high and 8½ × 4½ ft. in plan.

Tests of these transformers have given the following results:

| | |
|---|---|
| Iron loss | 22,600 watts. |
| Copper loss at full load | 8,700 " |
| Regulation | ½% |
| Efficiency, 100% full load | 98.3% |
| " 75% " | 98 % |
| " 50% " | 97.3% |
| " 25% " | 95.3% |
| Rise in temperature after 8 hrs. at full load | 45° C. |

That the iron loss is made comparatively large

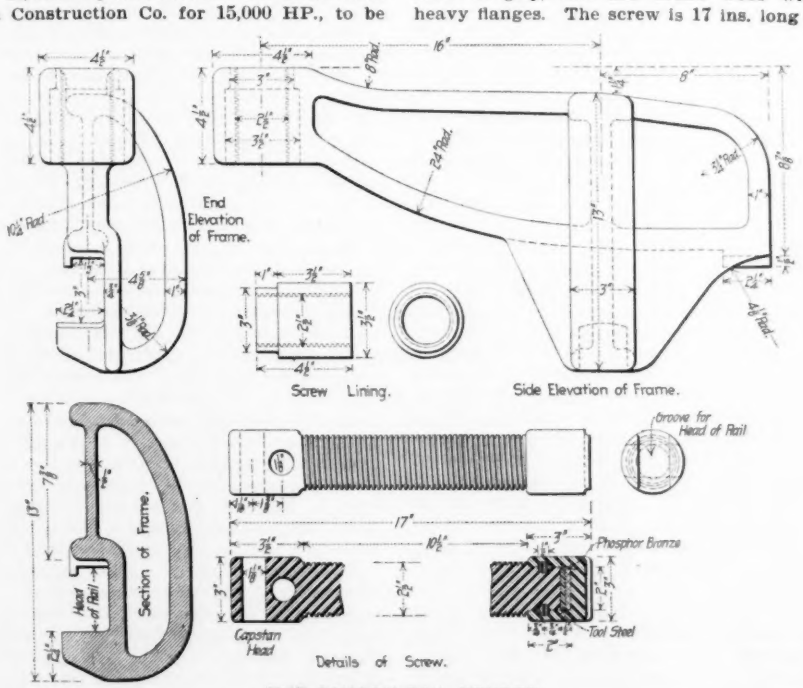
That the iron loss is made comparatively large is due to the low frequency, 25 cycles per second, for which the transformers are designed, and also to the high price of copper, together with the fact that operation will be continuously at the full rated capacity.

The transformers are immersed in oil, which is cooled by water circulating through 650 ft. of piping. The energy in the form of heat which must be disposed of in this way amounts to over 40 HP. at full load.

The information from which this article has been prepared was furnished to us by the General Electric Co., of Schenectady, N. Y.

## A NEW RAIL BENDER.

The accompanying illustration represents a somewhat novel device now in use on the Pennsylvania R. R. for bending and straightening rails. In most rail benders, the rail is held at two points, and pressure is applied at an intermediate point. In this machine, however, the rail is held by a claw on one end of a heavy lever, and pressure is applied by a capstan-headed screw at the other end. The screw is fitted with a cap, which bears against the rail, and in which the end of the screw revolves on a roller bearing. In the machine illustrated, the lever is 16 ins. long, from the center of the screw to the center of the claw or grip, and has broad webs with thick heavy flanges. The screw is 17 ins. long over all, 2½ ins. diameter over the threads, which are of square section, with four threads to the inch. Two ¼-in. washers, of tool steel and phosphor bronze, are placed between the screw and the cap. The lever, screw and cap are of cast steel, and the total weight is 113 lbs. This tool is styled the Samson rail bender, and is one of the specialties of the Q. & C. Co., of Chicago, Ill. We are indebted to that company for blue prints and particulars.




THE SAMSON RAIL BENDER.
Q. & C. CO., Chicago.

## THE MANUFACTURE OF STEEL FOR BUILDING CONSTRUCTION.*

By F. H. Kindl.†

(The first portion of the paper, which we omit, described in a popular way the processes which are gone through in the reduction of the iron ore, the conversion of the molten metal to steel, and its rolling into structural shapes. The paper then continues as below:—Ed.)

It is evident that for every different size beam, channel, or other shape, the entire set of rolls, from the cogging mill to the finishing rolls, must be changed; that is, the rolls and couplings must be removed and others put in their place. They must be re-set and lined up true, so as to produce the proper design and weight of shape in the finishing pass. The weight of material moved—that is, rolls, couplings, etc., to be re-set and relined—amounts to very nearly 175 tons in the large beam mill; and right here, gentlemen, it will become apparent to you that owing to the time required in roll changes we have a heavy factor in the time of delivery or, better, non-delivery in fixed time of your client's material. The cost of changing rolls, you can also see, must be considerable, and if we take but $1 per ton for labor of moving and re-setting we have at once $175, and a proportional amount for the smaller mills, noting that no account is made therein for the cost of skilled labor required to re-set and line up the rolls, taking from three to ten hours, depending upon the mill required to be changed.

A great deal of time is also required to change from one weight to the same shape and depth of another weight, so you can readily appreciate how it can occur that one building is erected so much quicker than another, and, I dare say, cheaper to your client, due simply to the use of standard sizes and shapes throughout in the construction of the steel skeleton, noting that the fewer the sizes used the quicker can the work be delivered. While this tendency toward the use of standard shapes has been very marked in the past few years, it could still be extended further, and it will no doubt interest you to know that in countries using the metric system architects and engineers long since adopted a standard of shapes, in conjunction with the mills, which are strictly adhered to, and none but the minimum weights in a fixed size are ever used. I am sure the sooner we adopt such a system the better it will be for all concerned.

But we must not forget our beam, which, no doubt, by this time, has left the last pass, or finishing pass of the rolls, and is now lying on the long roll table, ready to have a test piece cut from it and stamped with its blow number, representing the constituents of the steel, and to be cut into ordered lengths. The test piece is carefully prepared and sent to the testing laboratory, where its elastic limit, ultimate strength, and elongation and fracture are carefully measured and recorded, with the chemical constituents. The finished beam, cut to length, which has, until now, been lying flat on its side, is automatically turned up so as to rest on its flanges, as in its normal position in a building, and is quickly pulled across a series of rail skids, called cooling beds. Here it is allowed to rest until its turn comes to be straightened. The straightening machine is in direct line with the end of the cooling bed, and the beam is automatically guided through the machine, coming out of same true and ready to be shipped direct to destination, if plain, or transferred to the fitting shop, if work is to be performed thereon. Practically the same manner of manipulation as for beams applies to channels, rails, and other shapes.

For plates, the ingot is first reduced to a slab in the preparatory mill—called slabbing mill—which slab, as a rule, is reheated and then rolled flat to the required width and thickness in a plate mill. Plates having a width of over 48 ins. or less than ¼-in. thick are rolled in an ordinary plate mill—that is, one having only horizontal rolls—and plates rolled in such a mill must have their edges sheared in the direction of the length of the plate, subsequent to rolling and straightening. For plates under 48 ins. in width and over ¼-in. thick, this shearing is not necessary, as true edges can be obtained in a plate mill having, besides the same horizontal rolls as the ordinary plate mill, a set of vertical rolls. Such a plate mill is called a universal plate mill.

Plates 6 ins. and less in width are worked in grooves cut into rolls similar to those for shapes, and can be rolled in the same way as shapes. It being a less expensive process than that used for plates, most bars are rolled in this manner.

All plates, after being rolled to the required width and thickness, are apt to be buckled, owing to internal stresses or unequal heating at different points of the plate, and must be straightened by means of subsequent rolling. A set of these straightening rolls is placed in line with the feed table in the plate mill, and the plates are automatically conveyed through them, being still quite hot. They are then carried on a long roll table to the template department, and there laid off to template, all this being

*Extract from a paper read at the 33d annual convention of the American Institute of Architects, at Pittsburg, Pa.
†Structural Engineer, Carnegie Steel Company, Limited.

performed while the plate is on the roll table. They are then carried along to the shears, placed at the extreme end of the plate mill department, and cut to the template marked thereon. From here they are directly shipped to their destination.

Having now completed the rolling of our plain material, we will visit the fitting shop for beams, where all our beams and channels are sent to be fitted, i. e., either to be—

1st. Punched in web only, one or more size holes.
2d. Punched in flanges only, one or more size holes.
3d. Coped on one or both ends, after being punched.
4th. Riveted with connecting angles on one or both ends.
5th. Riveted into beam girders, with one or more cover plates.
6th. Bent or forged in blacksmith department.

As soon as the operation of the beams through one or more of the above processes is complete, i. e., when fitted as required by shop details, they are slid into the shipping yard on skids, ample room being left for this purpose between the different machines. Naturally, the less work to be performed, the sooner can the beam or other material be shipped, and in this respect the architect can materially assist in his plans and specifications. We will draw attention to some of the worthy points to be considered; noting, however, that they are not necessarily applicable in all cases, and good judgment must govern their use.

First. Specification, if possible, should call for only one size of hole to be used, namely, ¾-in. diameter, thus avoiding two operations and handling of material from one punch to another.

Second. Avoid coping by setting the floor beams sufficiently below the top flange of the main beam or girder, providing this latter is of sufficient depth.

Third. Avoid beam box girders, by the substitution of beams of greater depth.

Fourth. Avoid blacksmith work—that is, bending, welding, etc., by proper design of riveted members.

We now take a hurried look at the column shop, and here are found machines to perform the workmanship on the various classes of material, which, after first being laid off and punched, are assembled and subsequently riveted together to the finished column, which is then faced to the exact length; noting that all parts inaccessible after riveting are painted.

### Cost and Methods of Estimating.

The total cost of the structural steel erected in a building, of course, depends upon the weight required and the current quotations for the plain material, as well as upon the workmanship thereon, its hauling to and erection at the building site. The weight of structural steel in a building is very difficult to estimate, unless plans and specifications are first drawn up, as this will depend upon the design, the number of stories, the dead and live load to be carried per square foot of floor, the weight of brick or stone work resting on the outside girders, and the allowable unit stresses on the steel. While the allowable stresses per square inch are pretty well determined by our building laws, which are almost identical with each other, yet the former factors are of so wide range as to make each individual case different. However, for the weight of the steel skeleton of the average office building, whose walls are carried by the steel work, we have found by careful records of the weight of steel required that the following formula can be used with sufficient accuracy for preliminary estimates:

$W = N \times F (15 + 7/10\ N)$, in which "W" is the total weight in pounds of the structural material required: "N" is the number of floors, including the roof as a floor, and "F" is the number of square feet in each floor. The first number inside of the parenthesis when multiplied by the quantity N F, will give the weight of the beams and fittings required in the floors, while the second member multiplied by the same factor represents the weight of the columns. Thus we have for the weight of the skeleton steel for such a building, having a floor area of 10,000 sq. ft. and 15 stories high, 2,400,000 lbs. of beam work and 1,792,000 lbs. of column work, or a total of 4,192,000 lbs. of steel work.

As regards the cost, while this will vary somewhat, due to design, we might safely assume that unless the construction is complicated, owing to an irregular lot line or unusual construction such as is found in theaters, music halls, etc., the average cost for fitting beams will seldom exceed ½ ct. per lb. above the price of plain material, including the painting, and for column work, 1¼ cts. per lb. above the price of plain material. We have, therefore, for our building noted above, assuming that the price of plain material will average 2 cts. per lb., the cost of the beams would be 2½ cts. per lb., and that of the columns 3¼ cts. per lb., or a total cost of, beams, $60,000, columns, $58,240, and a total amount of $118,240 for the steel work f. o. b. cars Pittsburg, painted. To this must be added the cost of freight, hauling and erection. The hauling can generally be done for 50 cts. per ton, while the erection will seldom exceed $6.50 per ton, thus making the hauling and erection $7 per ton. The hauling and erection of the steel for our building would therefore be $14,672, making a total cost of $132,912 for the steel work, erected in Pittsburg, as per your plans and specifications. These figures are kept somewhat on the safe side, and appear high to-day, owing to the use of a base price of 2 cts. per lb. for the plain steel, which, as you know, is almost double the market price of one year ago.

Since writing this paper the price of steel has again advanced and the cost of our building would now be very nearly $15,000 more.

## LOCKS AND LOCK-GATES FOR SHIP CANALS.

In the Transactions of the Association of Civil Engineers of Cornell University, for May, 1899, Mr. Henry Goldmark, M. Am. Soc. C. E., contributes a paper upon locks and lock-gates in ship canals. As this paper is a resume of the whole subject, a brief abstract follows:

The credit of building the first canal lock is claimed by both Holland and Italy, but with conflicting evidence as to time and place. The first clear and distinct description of a lock with an enclosed chamber is believed to be found in "De re Aedificatoria," written by Leona Baltista Alberti in 1452. In 1618 Simon Stevinus, a Dutch scientist, also gave a good account of a canal lock. By some writers it is claimed that the first lock was built near Padua, in 1481; while Dutch writers assert that canal locks were in use in the Netherlands prior to 1250. It may also be added that the common canal lock is often called the Visconti lock, from its alleged inventor; and others again ascribe this invention to Leonerdo da Vinci; and he certainly does show a canal lock in his notebooks, still preserved.

According to location, locks are divided into two general classes: (1) Locks in inland canals and canalized rivers; (2) Locks in maritime canals and harbors. In the first series the "lift" is practically constant, and the water pressure against the gates always acts in one direction; locks in canals and harbors communicating with the ocean, act against a difference of level due to tides, and sometimes to wind action. In harbors the principal use of locks is for closing a dock entrance where the range of tide is considerable; as in the ports of the Bristol Channel, where this range is as much as 44 ft. In Liverpool alone there are more than 100 pairs of lock-gates closing openings of from 40 to 100 ft. width.

Few large ship canals have yet been built requiring locks; but the general dimensions of some of these are given, as follows: It should first be noted that while the canal proper requires a prism from four to six times larger than the cross-section of the vessel proposing to use it, any excessive size in the lock involves waste of water, lengthens the time of operation, and greatly increases the first cost of the lock. The new American lock, at Sault Ste. Marie, is designed to allow two vessels to pass, side by side, and this "fleet-lock" is 800 ft. long and 100 ft. wide. If the Lake vessels continue to increase in width and length, this lock will soon be unable to handle two ships at once, and the large width will then be worse than useless. The Canadian lock, finished in 1895, is 60 ft. wide and 900 ft. long, and appears to be better adapted to the demands of traffic. The proper width of locks for large ships is a troublesome problem, for the tendency seems to be to constantly increase this width. The large paddle-wheel steamers of 30 years ago caused several locks to be built 100 ft. wide at Liverpool and Havre. At present, few merchant ships are wider than 60 ft.; though the "Friedrich der Grosse" is 68 ft. wide, and the U. S. battleship "Iowa" is 76 ft. wide over all.

The North Sea-Baltic locks are 82 ft. wide; while the new Bremerhaven locks are 92 ft. wide. The Manchester Canal has 80-ft. and 65-ft. locks, with a narrower one alongside for smaller ships. The proposed locks for the Panama and Nicaragua ship canals are 59 ft. and 82 ft. wide.

The depth of water "on the sill" should equal the maximum draft of the boats or ships intended for traffic in it, plus a clearance of 1½ to 2 ft. As to "lift," few locks exceed 20 to 25 ft.; though the new locks of the St. Denis canal, in France, have a lift of 30 ft. In the Avonmouth dock, at Bristol, England, the range of tide is nearly 44 ft., and the lock-gates are figured to resist a pressure of 45 ft.; this lock has been in successful operation for nearly 30 years. The writer has designed lock-gates for lifts of 40 to 50 ft., with a width of 80 ft.

The integrity of a lock and the successful operation of the gates depends primarily upon its foundation; but here no general directions can be given, as each location requires its own treatment. The arrangement for filling and emptying the lock divides itself under the three following plans: (1) Valves in the upper gate. (2) Side culverts in the lock walls. (3) Culverts under the floor of the lock. The first plan has the merit of simplicity and in generally used in small locks. The openings are rectangular, and are placed as low as possible, so as to act with the greatest head. But these valves weaken the gate where the pressure is greatest; the water rushes in with such velocity as to often break the cables of vessels in the lock, and the time of filling is excessive for large locks. For these reasons, most large locks have culverts in the side walls or under the floors, for filling. The latter arrangement is only good where there is a rock foundation, to which one floor system can be bolted down so as to resist the tendency of the upward pressure of water to lift this floor. The most important examples of bottom culverts are to be found in the three great locks at Sault Ste. Marie; where 8-ft. rectangular openings are used; the head is about 19 ft., and the largest lock is filled in about 11 minutes, using four openings only. The side culverts, in the Manchester canal lock, are 6 ft. wide by 12 ft. high; similar culverts are used in the North Sea-Baltic canal. Three classes of valves are used in closing these culverts; slide-valves, butterfly-valves and cylindrical-valves. Rectangular slide-valves, of wood or metal, and provided with roller-bearings, are used on the Manchester and North Sea canals. In American locks, the butterfly-valve is generally employed, revolving on a central axis; cylindrical-valves are employed on French canals. The latter valves consist of vertical steel cylinders resting on a conical seat; they are raised vertically to admit the water through an annular orifice. As the amount of water that can pass through any one valve is small, these valves are expensive.

The lock-gates are complex in construction, and the successful operation of the lock depends largely on their correct design. Every lock must have at least two gates, with an intermediate one often added for shortening the lock and reducing time and consumption of water, for small vessels; and a guard-gate is also generally built at either end to allow the entire lock to be laid bare for repair or examination. The more important forms of lock-gates are the following: (1) The single-leaf revolving gate. This gate stretches across the lock, and is supported at the bottom and both sides, and acts as a girder instead of an arch. It is heavier than the double-leaf, which is another form of this type; requires more power to move it; shortens the available length of the lock, and costs about the same as a double-leaf gate. In France, single-leaf gates have been lately built up to 50 ft. in length. (2) The "tumble" gate also spans the canal with a single leaf; but it revolves on a horizontal shaft in the bottom of the canal. This form has been used at some of the Erie Canal locks for many years. (3) The sliding, or rolling gate, moves at right angles to the lock into a recess in the masonry, and when closed it acts as a truss supported by the side-walls and sill. It is used in England and on the Continent, and at Davis Island Dam, in this country. The foreign gates are built of iron, with closed air-chambers; the Davis Island gate is made of timber, and spans an opening of 110 ft. (4) Pontoons are sometimes rectangular, like the sliding gate, but also may be built with the outward curves of a vessel's hull. They are floated across the lock opening and sunk in position by admitting water into tanks in their interior. The pontoon bears against the inclined sides and sill, and is raised by pumping out the tanks, and it can then be floated into a recess in the masonry, out of the way. These pontoons are generally used in dry-docks. In the opinion of the writer, the double-miter-gate has so many strong points in its lightness, durability and facility of movement, that it is likely to hold its own even for large locks.

The machinery for opening and closing gates include turbine-wheels operated by water in the canal, hydraulic and electric power. The power

generated by the turbines is usually transmitted to the mechanism for moving the gate, by compressed air or electricity. The gates are generally moved by steel cables or chains, attached close to the bottom of the mitre-post. In recent locks, as at Barry, England, a stiff strut is substituted for the cables and is attached to the gate above water, and serves both to open and close the gate. One end of this strut connects directly to a plunger, that moves in a hydraulic cylinder which oscillates on a double axis placed in a recess built in the wall, approximately at right angles to the face

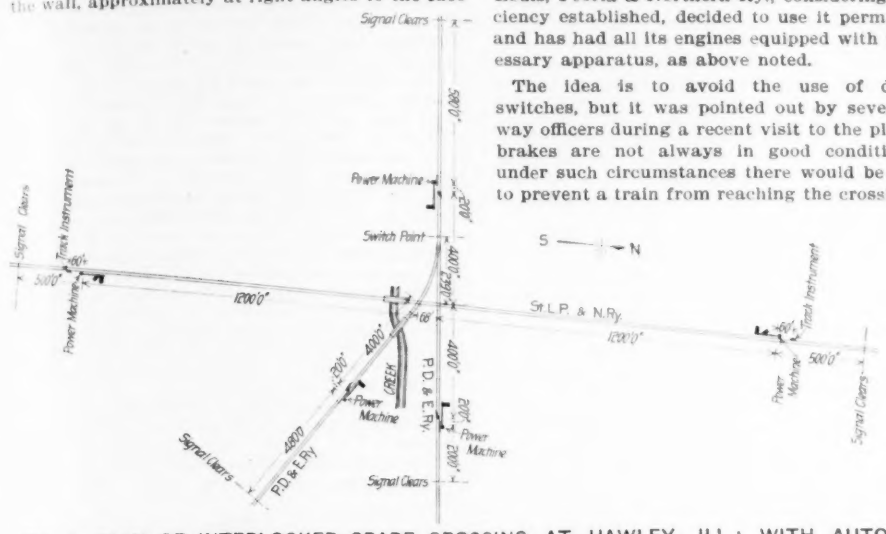



FIG. 1.—PLAN OF INTERLOCKED GRADE CROSSING AT HAWLEY, ILL.; WITH AUTOMATIC BRAKE-SETTING DEVICE ON THE ST. L., P. & N. RY.

of the wall. In the North Sea and Amsterdam canals a similar arrangement is used, with the strut carrying a rack connecting with geared spur-wheels. More recently electric motors have been substituted for water-pressure engines, and their use is likely to become general. Hydraulic machinery is always likely to give trouble in cold climates, and the transmission of power by pressure pipes to any distance involves expensive construction and costly repairs. In the Canadian lock at Sault Ste. Marie, electric motors are used for opening and shutting the gates, and for operating the large valves in the filling culverts.

## AUTOMATIC SIGNALING AND STOPPING OF TRAINS AT GRADE CROSSINGS.

The grade crossing of the St. Louis, Peoria & Northern Ry. and the Peoria, Decatur & Evansville Ry., at Hawley, Ill., has been equipped with an interlocking plant with automatic signals, supplemented on one line by the Rowell-Potter safety stop for automatically applying the brakes should a train try to run past a signal when set to indicate "stop." This automatic device, however, is only operative on the St. L., P. & N. Ry., which uses no derailing switches and whose engines (16 in number) are equipped with the necessary connections. The P., D. & E. Ry. uses derails, and therefore does not employ the automatic brake-setting device. Fig. 1 is a plan of the crossing. Fig. 2 shows the brake-setting track instrument, and the operating mechanism and valve on the engine.

A feature of the plant is that by means of track instruments on each line, the train movements are utilized to generate power to move the signals, this power being controlled by an electric current from a battery. It takes a pull of 100 lbs. to move the signal from the "stop" to the "clear" position, and the power machine furnishes this. Electricity simply unlocks the machine and allows it to move. The work of the battery is very small, about 2½ amperes for one-tenth of a second for each signal movement. The plant was originally installed for experimental purposes, but the St. Louis, Peoria & Northern Ry., considering its efficiency established, decided to use it permanently, and has had all its engines equipped with the necessary apparatus, as above noted.

The idea is to avoid the use of derailing switches, but it was pointed out by several railway officers during a recent visit to the plant that brakes are not always in good condition, and under such circumstances there would be nothing to prevent a train from reaching the crossing even with the signals set against it. Accidents of more or less importance are continually being caused by brake failures, and several such accidents have occurred at crossings. For these reasons, the objections which railway men make to the substitution of a brake-setting device for an interlocked derail are very easily understood.

In one of the tests, a St. L., P. & N. Ry. train of six cars was run at the crossing at a speed of 40 miles an hour, when the signals were set against it in consequence of another train standing on the intersecting line. By means of the track instrument the brakes were automatically set as the engine passed the semaphore signal, 1,200 ft. from the crossing, and the train stopped 300 ft. from the crossing. It was pointed out, however, that had the brakes failed to work the train would have gone over the crossing at a speed of probably 10 miles an hour. Had the test been made on the P., D. & E. Ry., however, the derails would have prevented the train from reaching the crossing even if the brakes had failed.

The following are the rules and regulations issued by Mr. W. H. Gridley, Superintendent of the St. Louis, Peoria & Northern Ry., in regard to the interlocking plant at the Hawley crossing:

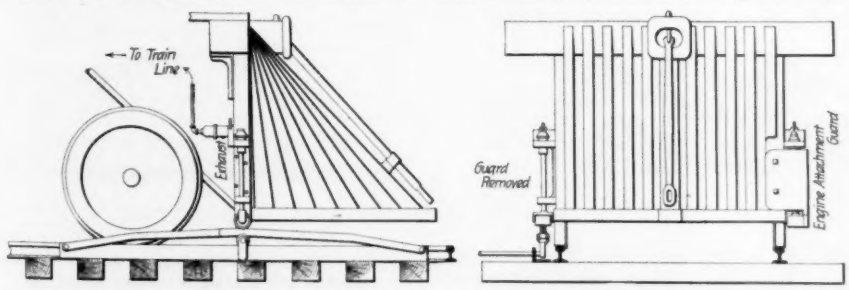



FIG. 2.—TRACK INSTRUMENT AND LOCOMOTIVE EQUIPMENT FOR THE ROWELL-POTTER AUTOMATIC BRAKE-SETTING DEVICE.

All signals, excepting the green blades, which are indicator blades, are normal danger signals, and if the crossing is unoccupied, will clear for an approaching train 500 ft. in advance of the same. The indicator or green blade is at safety at all times, excepting when the circuit is occupied by trains of opposing line, thus indicating in advance whether the home signal will clear or not. Hence, if the crossing is clear for trains to proceed, the indicator or green blade will stand at safety, and the red one at danger, the red one clearing on approach of train, as above stated.

Should the indicator or green blade stand at safety and the red one fail to clear, it is an indication that the signal is out of order, and this fact must be reported from the first telegraph office.

The circuits which operate the St. Louis, Peoria & Northern signals are controlled by both the Peoria, Decatur & Evansville relays, and the P., D. & E. signals, so that should a P., D. & E. signal fail to go to danger and open the derail on P., D. & E. track to the full stroke, the St. Louis, Peoria & Northern signal will not clear, even though all of the P., D. & E. relays should properly recover.

The circuits which control the P., D. & E. signals are in like manner controlled by both the St. L., P. & N. relays and signals, so that should either of the St. Louis, Peoria & Northern signals fail to make their complete movement to danger, none of the P., D. & E. signals will clear.

Signals on both sides of the crossing on the St. Louis, Peoria & Northern track are cleared by one and the same movement for trains within the limits of the circuit, as it is necessary to drop both track instruments to allow trains to pass, and this is equally true of the P., D. & E. signals, as it is necessary to close both derails.

In the event of the failure of the plant to work as indicated in these rules and regulations, trains will use proper precaution to flag themselves safely over the crossing and report failure by wire immediately upon arrival at the first telegraph office.

The plant was put in by the Rowell-Potter Safety Stop Co., of Chicago, Ill. Our readers will remember that this device was used on the electric elevated railway at the Columbian Exhibition, and it is in service at some points on the Chicago elevated loop railway and the Metropolitan Electric Elevated Ry., of Chicago.

## THE PROVISION FOR STORM WATER IN SEWAGE PURIFICATION WORK.*

By A. J. Martin, Assoc. M. Inst. C. E.

The difficulty of dealing with a matter of sewage disposal is nearly always aggravated by the large volumes of rain water which find their way into the sewers. It might, therefore, seem desirable that surface water should be kept out altogether; but it is now recognized that it is practically impossible to exclude all rain water from any system of sewers. Even where road water is excluded, the drainings from back yards and back slopes of roofs are generally admitted to the sewers, both on account of the expense of constructing a duplicate system of sewers and because of the serious objections to the existence of two sets of drains on private property. If the whole of the water so admitted had to be dealt with in the purification works, the size and cost of these would in most cases be greatly increased.

The decision how much storm-water works shall be called upon to deal with is one presenting great difficulty, owing to the number of considerations involved. The matter may be approached from at least three different points of view:

(a) The extent to which sewage shall be diluted before a storm overflow takes place.

(b) The frequency with which a storm overflow may take place.

(c) The relation between the volume of the sewage and that of the stream receiving the storm overflow.

It is hardly necessary to point out that a rigid adherence to any of these bases without regard to all the circumstances of the case will produce exceedingly anomalous results.

(a) The first basis is probably the weakest in principle; but it possesses the important practical merit of being the most easily applied, and has accordingly been adopted by the Local Government Board in the rules which they have recently laid down. These may be briefly stated as follows:

As at present advised, the Board considered that whatever system is adopted as a means for dealing with the sewage, it is necessary that provision should be made in the scheme for (1) treating fully as ordinary sewage a volume of mixed sewage and storm water equal to three times the daily dry weather flow of sewage, and (2) dealing with the excess of storm water up to six times the dry weather flow, or a balance of three times the dry weather flow, either by passing it through a special and separate storm filter of sufficient extent, or by delivering it on a special area of prepared land other than that in use for the treatment of the effluent from the ordinary tanks and filters. . . . . If a special storm filter is provided for this purpose, it should be of sufficient extent to allow a rate of filtration of 500 gallons per square yard per diem.

In applying these rules, we are brought face to face with the wide differences which exist in the volume of the dry weather sewage per head of population in different towns. These are due to various causes; for instance, greater or less lavishness in the use of water for domestic purposes, water used for trade purposes, waste of water, the admission of brook water, and the infiltration of subsoil water into the sewers. If the dry weather flow is regarded as including the extraneous water which finds

*Condensed from a paper read before the Sanitary Institute, at the recent Southampton Congress.

its way into the sewers, the quantity to be dealt with in the works will be correspondingly increased, and we shall have the anamalous result that the diluted sewage which one public body may discharge without treatment, will be considerably stronger than that which another authority will be called upon to purify.

The anomaly will be reduced if extraneous water is ignored, and the actual water supply taken as the basis on which the size of the works is computed; but we are still met with the wide discrepancies which exist between the quantity of water supplied in different towns. It would therefore seem reasonable that a certain number of gallons per head should be laid down as the quantity to be dealt with in all cases; or perhaps, better still, that a sliding scale should be established, based upon the average ratable value of the houses draining to the works. Any waste water from factories would have to be added to the sewage proper.

(b) A consideration at least equal in importance to the extent of dilution at the time of overflow is the frequency with which such overflow takes place. The sewage of some towns is permanently diluted with subsoil water to such an extent that it might be discharged without any treatment if the amount of dilution were the only consideration. In other cases the area draining to the sewers is so great that the overflow weirs will be brought into use by a rainfall of a few hundredths of an inch, and consequently when the streams receiving the overflows are not swollen appreciably above their dry weather volume. In such a case as this a high degree of dilution of any storm discharge is certainly desirable. By way of contrast, a case may be taken where no surface water other than that from back yards and the back slopes of roofs finds its way into the sewers. One thousand houses may conveniently be taken as a unit. The dry weather sewage from 1,000 houses, at 5 people per house, and 20 gallons per head per day, would amount to 100,000 gallons per day. Taking the surfaces draining to the sewers as averaging 600 sq. ft. per house, we have a total area of 600,000 sq. ft. Each one-hundredth of an inch over this area equals 500 cu. ft. The amount of diluting water which the Local Government Board require to be dealt with before a storm overflow comes into operation would be five times the dry weather flow, or 500,000 gallons, equal to 80,000 cu. ft. per day. This represents a rainfall at the rate of 1.60 ins. per 24 hours, or a still larger fall when loss by absorption and evaporation is taken into account. It would clearly be a hardship that a town which only uses its storm overflow when this rate of rainfall is exceeded, and when consequently the streams are swollen, should be called upon to dilute its sewage to the same extent before using its overflow weir, as another town in which an overflow takes place after a rainfall of a few hundredths of an inch.

(c) The important point after all is not the rate of dilution of the storm water as it leaves the sewers, but the resulting dilution in the stream into which it is discharged. The volume of the stream is therefore a factor of prime importance in dealing with this question.

While emphasizing the need for paying attention to the frequency of operation of a storm overflow and the resulting dilution in the stream, rather than the amount of dilution at the moment of discharge, we are bound to recognize the fact that a given dilution of the storm water in the sewer can be provided for with some degree of certainty, while it would be difficult to regulate the frequency with which such overflow takes place, or the degree of dilution which shall ensue in the stream receiving it. It would, therefore, be impossible to make either of these last-named factors the basis of a definite rule; but they should nevertheless be borne in mind in dealing with any particular case.

Having determined the amount of storm water with which works shall be capable of dealing, the next question which arises is the manner in which the storm overflow shall be brought into action. The Local Government Board insist that fixed weirs shall be used, which will only come into operation when the sewage has been diluted with five times its volume of storm water, that is to say, when a certain rate of flow in the sewer is reached. The advantages of a fixed weir as compared with a movable one are obvious; but there are grave objections to any overflow which depends upon the rate of flow in the sewer at any moment. Such an overflow will necessarily come into operation before the flow to the works reaches the maximum with which they are laid down to deal. This point will be best explained by means of a concrete example. A 24-in. sewer at a gradient of 1 in 400 will deliver a maximum quantity of 792 cu. ft. per minute, when filled to a depth of 22½ ins. An overflow weir 4 ft. long, having its crest at two-thirds the height of the sewer, will reduce the depth of flow in the latter to about 18¾ ins., giving about 2¾ ins. on the crest of the weir. The latter will carry off some 90 cu. ft. per minute, leaving 702 cu. ft. per minute to flow down the sewer to the works, which must therefore be capable of dealing with this quantity. The storm overflow, will, however, begin to take place long before this rate is attained, viz., when the surface of the sewage reaches the crest of the overflow weir. The flow to the works will then be at the rate of 577 cu. ft. per minute, or just over four-fifths of what they are capable of dealing with. The degree of dilution will be still further reduced if the storm overflow takes place when the volume of sewage proper is greatest. In large towns the maximum dry weather flow will generally not exceed twice the average, but in smaller communities the proportion will be two and a half times, or even more. The amount of dilution secured by a fixed weir is therefore variable, and will at times be considerably less than the works are intended to secure.

The Rivers Pollution Commissioners, in their report already quoted, point out that the earlier portions of storm water are more polluting than dry-weather sewage. The polluting matter is derived partly from the surfaces draining to the sewers, and partly from old deposits in the sewers themselves. The greater and more sudden the rush of storm water, the larger will be the proportion of polluting matter which it sweeps through the storm overflow. The protection afforded to a water-course by the enforcement of a certain degree of dilution is thus inconsiderable. It is therefore exceedingly desirable that the whole of the storm-flow should be dealt with in the purification works—so far, at least, as its earlier stages are concerned. In works of sewage purification which he is called upon to design the author accordingly prefers to treat the whole overflow of the outfall sewer, so long as it contains the first scourings from the sewers and surfaces drained.

The means by which this is accomplished will be best explained by describing the arrangement adopted in an installation which was recently designed by the firm of which he is a member, and laid down under the superintendence of Mr. Wardlaw, C. E., of Glasgow, to deal with the sewage of Barrhead. These works are intended to serve 10,000 people, and to deal with a maximum flow of 400,000 gallons per day. If the dry-weather flow is taken at 20 gallons per head, or 200,000 gallons per day, the ratio of maximum to ordinary flow will be two to one, or two-thirds of what is now enforced in England. The author submits, however, that by reason of the means adopted for dealing with the first rush of storm water, these works afford a more efficient safeguard against the pollution of the river than if the provision had been 50% greater, and the storm overflow made to depend directly upon the rate of flow in the sewer. The overflow weir is placed in the grit chambers, and extends the whole length of the dividing wall between them. Its crest is 18 ins. above the ordinary working level of the sewage in the septic tanks. No overflow can take place until the intermediate space, amounting to 10,800 cu. ft., has been filled up. The tanks are therefore capable of receiving for some considerable time the whole flow of the sewer, however great it may be. The actual time varies, roughly speaking, inversely with the rate of flow. Thus a flow at the rate of 3,600,000 gallons per day, or 18 times the assumed dry-weather flow, will be dealt with by the works during the first half-hour; with 2,000,000 gallons per day, or 10 times the dry-weather flow, the time will be one hour; with 1,200,000 gallons per day, or 6 times the dry-weather flow, two hours; and so on. In each case the coming into action of the storm overflow will be deferred for the period mentioned; and if the storm flow should be of short duration, as in the case of a thunder-shower, no overflow whatever will take place. The regulation of the flow through the works is effected at the outlet from the tanks, and is therefore not liable to be interfered with by solid matter, as would be the case with any regulating arrangement at the inlet thereto. The regulators at Barrhead consist of a couple of modules; but in other cases the alternating gear which actuates the valves of the filters may be so arranged as to control the quantity of sewage passing through the works.

In order that the provision for dealing with storm water may exist in reality, and not merely on paper, the purification works should be capable of quickening their pace so as to deal with the maximum quantity for which they are designed, however suddenly it may reach them; or a man should be constantly in attendance to bring this about. Unless proper provision is made to receive storm water at any time, whether expected or not, it is little better than waste of money to provide works for dealing with it. The working of the installation already referred to, as well as that of others on the same system elsewhere, conforms itself immediately and automatically to the rate of flow at any time.

An overflow weir should always be masked by a scum slab, so that floating solids may not escape thereby, but may pass on to be dealt with in the purification works.

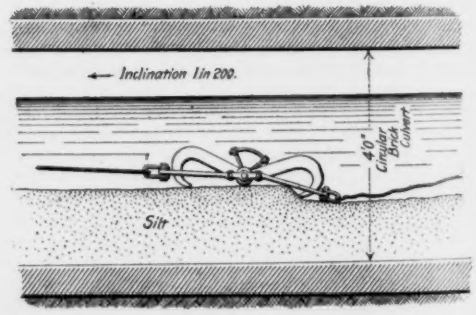
If the Local Government Board's requirement, that works of sewage disposal should be capable of dealing with three times the drw-weather flow, necessitated a corresponding increase in the size of the works, the expenditure involved would cast a heavy burden upon the ratepayers. Fortunately, however, this is not the case. Purification works on the biological principle, and to a certain extent doubtless those on other systems, are capable of dealing temporarily with volumes of dilute sewage far exceeding the quantities of ordinary sewage which can be safely passed through them continuously. A good deal of misapprehension prevails on this point. It has been assumed that a septic tank in particular is liable to be thrown out of gear by storm water passing through it, and pathetic pictures have been conjured up of hapless microbes torn from their moorings by a torrent of storm water passing through the tank. These apprehensions become ridiculous as soon as the facts of the case are examined. The velocity of flow in the tanks at Barrhead, for instance, with three times the volume of the dry-weather sewage passing through them, as required by the English Board, would be 1⅛ ins. per minute. With six times the dry-weather flow passing through the tanks, the velocity would not exceed 3¾ ins. per minute, which is utterly powerless to disturb the solid matter therein. In all cases where the outfall sewer is not excessively large for the work it has to do, it is safe to say that it might discharge full bore into the tanks without any deleterious effect upon them. The influence of an occasional storm flow, is, indeed, beneficial rather than harmful, inasmuch as it carries away with it the products of the action of the bacteria both in the tanks and filters, thus stimulating their activity to a corresponding extent.

The principle conclusions which have been arrived at in the foregoing paper may be briefly stated as follows:

1. That no definite rule as to the proportion of storm water to be dealt with can be applicable in all cases.
2. That the first scourings of the sewers and surfaces drained should pass into the ordinary works before any overflow is allowed to take place.
3. That the works provided for dealing with storm water should always be ready to receive it at any hour of the day or night.
4. That a reasonable provision may be made for dealing with storm water without adding unduly to the cost of works.

## SEWER CLEANING DEVICE USED AT WALSALL, ENG.

The accompanying sketches show a device used to remove a 15 to 18-in. deposit from a 4-ft. brick outfall sewer, at Walsall, Eng. The sewer was on a grade of 1 in 2,000, and the deposit extended over a length of about ¾-mile. The deposit was the accumulation of many years, and included road detritus, sand and coal dust, the two latter materials being attributed to foundry wastes. The cleaning device shown weighed about 550 lbs. The wrought-iron claws, ten on each side, work on a common axle, which permits them to pass over irregularities in the invert. The bars above the axle prevent the claws from doubling over backwards. The device was moved through the sewer by means of two steam-plowing engines, connected to each end by wire ropes. The upper engine first hauled the device slowly upstream, after which the other engine pulled it swiftly back, causing a current to accompany it, and thus washing the material previously loosened out through an open carrier. The work was done in sections, the length of which is not stated. We are indebted to "The Surveyor" for the originals from which the sketches were redrawn, and for the notes given above. The original description formed a part of a paper on the Walsall sewerage works read before the Association of Birmingham Students of the Institution of Civil Engineers, by Mr. R. J. Angel, Assoc. M. Inst. C. E., Surveyor to the Vestry of Bermondsey, and formerly Assistant Borough Engineer of Walsall. Mr. Angel does not state who designed the sewer cleaner, but gives credit for the design of portions of the works to Mr. R. H. Middleton, Assoc. M. Inst. C. E., Borough Engineer of Walsall.




DEVICE FOR CLEANING SEWERS USED AT WALSALL, ENG.